



---

# Capstone MicroTurbine

## Model C65 User's Manual

### (Software Version 5.XX)

---



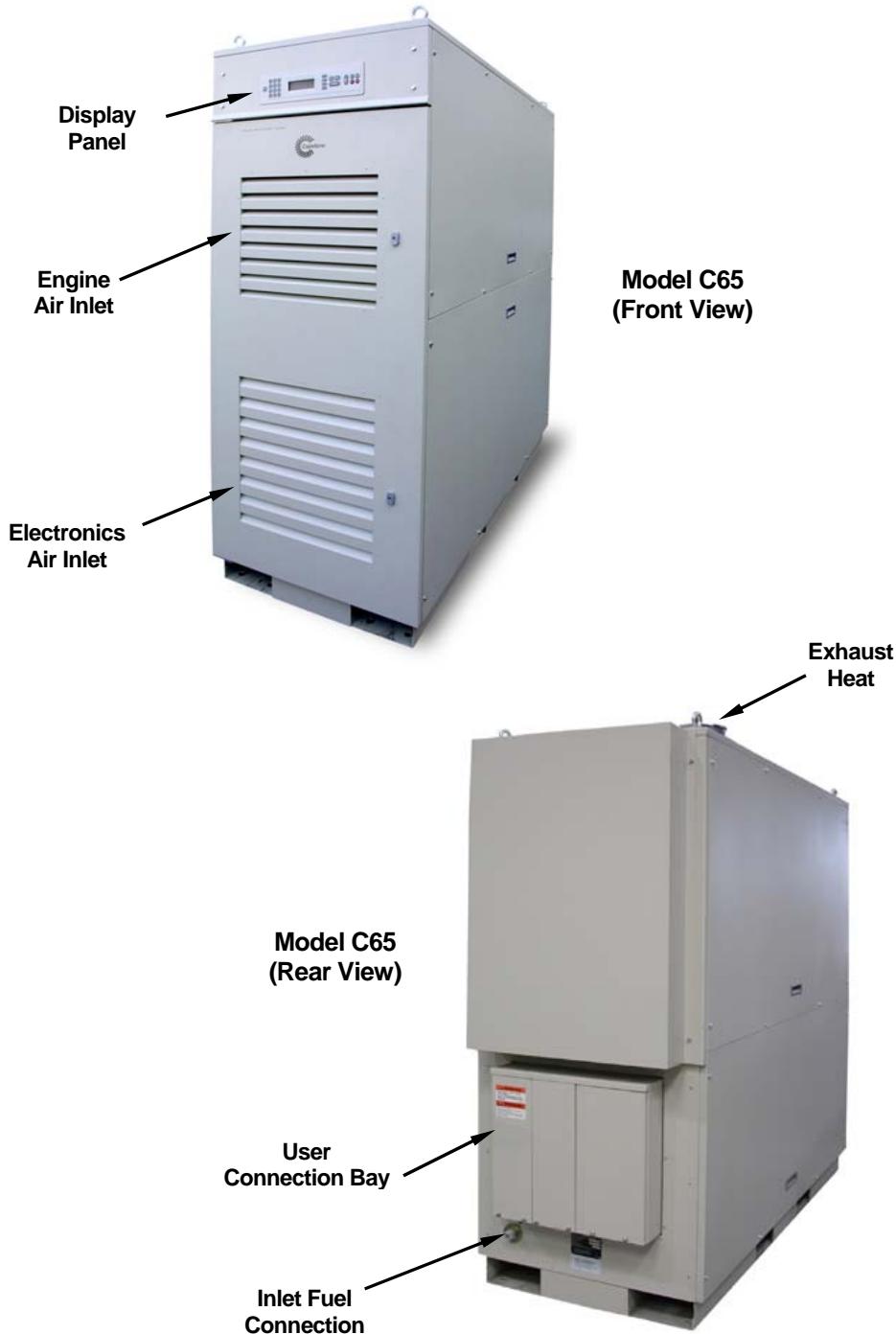
Capstone Turbine Corporation  
21211 Nordhoff Street, Chatsworth, California 91311 USA

Copyright © 2007 Capstone Turbine Corporation. All rights reserved.

CAPSTONE and the turbine blade logo  are Registered Trademarks  
of Capstone Turbine Corporation.

MicroTurbine™ is a Trademark of Capstone Turbine Corporation.

Welcome to the world of Capstone Power Generation!  
We are pleased that you have chosen the Capstone MicroTurbine product  
for your application.



## Table of Contents

About This Document.....	7
Safety Information .....	7
Introduction .....	7
Symbols .....	7
General Precautions .....	8
Electrical Precautions .....	9
Fuel Precautions .....	9
Exhaust Precautions .....	10
Acoustic Emissions Precautions .....	10
Certifications, Permits, and Codes.....	11
Document Overview .....	11
MicroTurbine Introduction .....	11
Key Mechanical Components .....	12
Main Features .....	12
MicroTurbine Engine .....	13
Controller .....	13
Air Bearings .....	13
Fuel System.....	13
Emissions .....	13
Enclosure.....	14
Stand Alone Option .....	14
Distributed Generation .....	14
Integrated Combined Heating and Power (ICHP) Option.....	14
Offshore Option .....	15
Operational Features .....	15
Peak Shaving .....	15
Combined Peak Shaving and Standby .....	15
MultiPac Power .....	15
Resource Recovery.....	15
ICHP Electrical and Thermal Recovery.....	15
OEM Applications .....	16
Output Measurements .....	16
ISO Conditions .....	16
Pressure .....	16
Volume.....	16
Heating Values .....	16
MicroTurbine Performance .....	16
Grid Connect Output .....	16
Stand Alone Output.....	17
Power Quality .....	17

---

Heat Output .....	17
Operating the MicroTurbine .....	17
Basic MicroTurbine (MT) Operation .....	17
Routine Operation .....	17
Communications .....	18
Routine Operation Data .....	18
Control Device Authority and Priority.....	18
Start-up .....	19
Shutdown.....	19
Emergency Stop (E-Stop).....	19
Restart .....	20
Using the Display Panel.....	20
Display Panel Areas.....	20
Menu Navigation .....	21
Display Panel Data Entry .....	21
Logging On with a Password .....	22
Changing the Password.....	22
Display Panel Menus - Overview .....	22
System Data Menu .....	24
Turbine Output Submenu .....	24
Clear Fuel Fault Submenu.....	25
Vent Monitor Submenu .....	25
System Configuration Submenu.....	26
Power Connect Submenu .....	26
MultiPac Submenu .....	27
Turbine Number Submenu.....	27
Auto Restart Submenu .....	27
System Demand Submenu.....	27
Control Access Submenu .....	28
Enter Password Submenu.....	28
Logoff Submenu.....	28
Reboot Submenu .....	29
Grid Connect Menu .....	29
Stored Demand Submenu .....	29
Under Voltage Submenu .....	30
Over Voltage Submenu.....	30
Fast Under Voltage Submenu .....	31
Fast Over Voltage Submenu .....	31
Under Frequency Submenu .....	31
Over Frequency Submenu .....	32
Enable Mode Submenu .....	32
Reconnect Delay Submenu.....	32
Stand Alone Menu .....	33
Voltage Submenu.....	33

---

Under Voltage Submenu .....	34
Over Voltage Submenu.....	34
Frequency Submenu.....	34
Under Frequency Submenu .....	35
Over Frequency Submenu .....	35
MultiPac Minimum Power Submenu .....	35
Fast Transfer Delay Submenu.....	36
Stand Alone Load Wait Submenu .....	36
Local Battery Charge Submenu .....	36
Unit Data Menu .....	37
Using the User Interface Port.....	38
Capstone Remote Monitoring Software .....	39
MicroTurbine Operating Modes .....	39
Grid Connect Operation.....	39
Grid Connect Dispatch .....	39
Configuring Grid Connect.....	39
Grid Connect Interlock.....	39
Grid Connect Mode Enable.....	40
Starting a Grid Connect System .....	40
Stopping a Grid Connect System .....	40
Grid Connect Power Demand.....	40
Stand Alone Operation.....	40
Configuring Stand Alone .....	41
Stand Alone Interlock .....	41
Stand Alone Mode Enable .....	41
Stand Alone Battery.....	41
Stand Alone Battery Isolation Switch.....	41
System Sleep in Stand Alone Mode .....	41
Waking a Stand Alone MicroTurbine.....	42
Starting a Stand Alone System.....	42
Enabling Stand Alone Power Output.....	42
Stand Alone System Power Level .....	42
Disabling Stand Alone Power Output.....	42
Stopping a Stand Alone System.....	43
Dual Mode Operation.....	43
Capstone Dual Mode Controller .....	43
Configuring Dual Mode.....	44
Setting the System for Dual Mode Operation .....	44
Switching Times for Dual Mode .....	44
MultiPac Operation.....	44
MultiPac Grid Connect Operation .....	44
MultiPac Stand Alone Operation.....	45
MultiPac Enable/Disable .....	45
Changing the Master Unit in a MultiPac .....	45
ICHP Operation .....	46

---

---

MicroTurbine Preventive Maintenance.....	47
Scheduled Maintenance .....	48
C65 Stainless Steel Package – Gaseous Fuels .....	49
Preventive Maintenance .....	50
MicroTurbine Inlet Air Filter.....	50
External Fuel Filter .....	50
Battery Maintenance During Storage .....	51
Battery Charge Management .....	53
Manual Battery Pack Equalization Charge.....	53
Warranty .....	53
Troubleshooting .....	54
Incidents.....	54
Incident System Severity Levels .....	54
Incident Names and Codes.....	54
Internal Incident.....	55
Fuel Incident .....	55
Grid Incident .....	55
Lo-Temp/Hi-Temp/Hi-Alt Incident.....	55
E-Stop Incident.....	55
User Connection Incident.....	55
Viewing Incident Records .....	56
Basic Troubleshooting Procedures .....	56
No Lights on Display Panel.....	56
No Attempt to Start after ON Command .....	57
Start Attempt Fails.....	57
Low Power Output.....	57
Unexpected Shut Down or Warning .....	57
Product Support .....	59
Reference Documents .....	61
Capstone Contact Information .....	61
Capstone Applications .....	61
Capstone Technical Support.....	61
Capstone Technical Support (Japan) .....	61



## About This Document

This document provides user instructions to operate and maintain the Capstone Turbine Corporation Model C65 MicroTurbine.

This document is intended for user personnel who may not have specific training on the MicroTurbine (sometimes abbreviated as MT in this manual). Capstone Authorized Service Providers (ASPs) have received rigorous training and have been certified to perform commissioning, troubleshooting, and repair of the MicroTurbine. This document reflects C65 MicroTurbine with software version 5.XX, which meets the requirements of IEEE 1547.1 and the revisions to UL1741 compliance updates effective May 2007.

**User personnel who have not received certification of satisfactory completion of the Authorized Service Provider training should not attempt any procedures other than those specifically described in this document.**

## Safety Information

This section presents safety information for the user of Capstone Turbine Corporation MicroTurbines. The user must read and understand this manual before operation of the equipment. Failure to obey all safety precautions and general instructions may cause personal injury and/or damage to the equipment.

**It is the user's responsibility to read and obey all safety procedures and to become familiar with these procedures and how to safely operate this equipment.**

## Introduction

The Capstone MicroTurbine is an advanced power generation system with user and material safety foremost in mind. Fail-safe operation includes mechanical systems, electrical systems, and engine control software.

## Symbols

There are three very important symbols used in this document: Warnings, Cautions, and Notes. **WARNINGS** and **CAUTIONS** alert you to situations and procedures that can be dangerous to people and/or cause equipment damage. **NOTEs** provide additional information relating to a specific operation or task.

<b>WARNING</b>	A Warning means that personal injury or death is possible.
<b>CAUTION</b>	A Caution means that damage to the equipment is possible.
<b>NOTE</b>	A Note is used to clarify instructions or highlight information that might be overlooked.

## General Precautions

The following general precautions must be observed and followed at all times. Failure to do so may result in personal injury and/or equipment damage.

**NOTE**

Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.

- **Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.**
- Read and understand the User's Manual before operating the equipment.
- Read and obey all warnings and cautions.
- Make sure all fuel connections are tight, free from leaks, and protected from damage.
- Make sure all electrical connections are tight, clean, dry, and protected from weather and damage.
- The MicroTurbine may be equipped with a heat recovery system. Use caution around relief valves where hot water and steam may be present.
- On offshore oil applications, the pressurized enclosure (Class I, Division 2 option) should not be opened: 1) Unless the area is known to be free of flammable materials; 2) All devices have been de-energized from the utility. Power should not be restored until the enclosure has been purged for three minutes.
- Use hearing protection when you work on or near an operating MicroTurbine for extended time periods.
- The MicroTurbine is heavy. Be careful when you move or lift the MicroTurbine.
- Keep the equipment clean.
- Keep all flammable materials away from the MicroTurbine and its components.
- Do not operate or work on the equipment if mentally or physically impaired, or after consumption of alcohol or drugs.
- Make sure all fasteners are installed and properly tightened.
- Keep an ABC rated fire extinguisher near the MicroTurbine.
- Obey all applicable local, state, and national codes and regulations.

## Electrical Precautions

The output voltage and residual capacitor voltage of this equipment is dangerous. High voltage can kill or injure. Use caution when you work on electrical equipment. The MicroTurbine system can include multiple sources of power. Turn off the system and lockout the power supply prior to all work on the equipment.

<b>NOTE</b>	Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.
-------------	--

Prior to doing any installation or work on a Capstone MicroTurbine:

- Make sure the MicroTurbine is commanded to OFF.
- Open and lock the dedicated disconnect switch to isolate the MicroTurbine from the electric utility grid or loads.
- If the MicroTurbine is equipped with a battery pack (i.e., if the MicroTurbine includes the Stand Alone Option), open the battery isolation switch and unplug the battery cable.
- Wait five (5) minutes for any capacitive stored voltage to dissipate.
- Always disconnect all power sources.
- Use a voltmeter to make sure that all circuits are de-energized.
- All output connections must be made in accordance with applicable codes.

<b>WARNING</b>	The MicroTurbine system contains and produces high voltage. High voltage can injure or kill. Obey all safety procedures when you work around electrical equipment.
<b>WARNING</b>	Make sure the system is off and the dedicated disconnect switch is in the open position and is locked. This will help prevent injury and damage to the equipment.

## Fuel Precautions

The Capstone MicroTurbine operates on approved gaseous fuels. Keep flames, sparks, pilot lights, equipment that produces electrical arcs, switches or tools, and all other sources of ignition away from areas where fuel and fumes are present. If there is a fire, use a multi-purpose dry chemical or CO<sub>2</sub> fire extinguisher.

Fuel lines must be secure and free of leaks. Fuel lines must also be separated or shielded from electrical wiring. If you smell fuel fumes, immediately stop operation of the equipment, close the fuel isolation valve, and locate and repair the source of the leak or call a qualified professional.

<b>WARNING</b>	MicroTurbine fuel is flammable and explosive. An explosion can cause death or injury to personnel and/or damage to equipment. No open flame or smoking is allowed near the MicroTurbine.
<b>WARNING</b>	Gaseous fuels can be corrosive. Concentrations of Hydrogen Sulfide (H <sub>2</sub> S) can be found in Sour Natural Gas and Sour High Btu Gas. Injury to personnel and/or damage to equipment can occur. Minimize exposure to gaseous fuels and provide satisfactory fresh airflow when you are around equipment.

## Exhaust Precautions

The Capstone MicroTurbine is designed to produce very clean emissions. The exhaust is clean and oxygen rich (approximately 18% O<sub>2</sub>), with very low levels of air pollutants. Like all fuel combustion technology, the MicroTurbine can produce potentially harmful emissions (like nitrogen dioxide and carbon monoxide) from the fuel combustion process. Although the MicroTurbine has ultra low nitrogen dioxide (NO<sub>2</sub>), and carbon monoxide (CO) emission levels, make sure precautions are taken to prevent personnel from being exposed to nitrogen dioxide and carbon monoxide while the system is operating. Nitrogen dioxide and carbon monoxide are poisonous at high concentrations.

When installed indoors, the MicroTurbine exhaust must be vented to the outside. Make sure there is a satisfactory fresh air supply. An exhaust system must be added to direct the exhaust away from the system to reduce the risk of exposure to dangerous emissions.

For exhaust connection data, temperatures, pipe requirements, and other related information, contact your Capstone Authorized Service Provider.

When installed outdoors, the MicroTurbine should be located where there is a satisfactory fresh airflow so the exhaust emissions will be dissipated.

<b>WARNING</b>	The MicroTurbine exhaust contains nitrogen dioxide and carbon monoxide, which are poisonous at high concentrations. Make sure there is satisfactory fresh airflow when you work around the equipment.
<b>WARNING</b>	The exhaust airflow and pipes are hot enough to cause personal injury or fire. The exhaust airflow can reach temperatures as high as 371 °C (700 °F). Keep people, equipment, and other items away from the exhaust airflow and pipes. Always vent exhaust away from personnel.
<b>WARNING</b>	Hot surfaces and hot exhaust can be dangerous. Personal injury and/or damage to equipment are possible. Be careful when you work on equipment.

## Acoustic Emissions Precautions

The Capstone MicroTurbine is designed to produce safe acoustic emissions. However, when working at a radius of 10 meters (or 33 feet) from an enclosed Capstone MicroTurbine, sound level exposure will average approximately 70 dBA.

Capstone recommends that hearing protection be worn when working on or in the immediate vicinity of operating MicroTurbines for extended time periods.

Other acoustic emissions regulations may apply to your specific installation location. Always check to be certain that your installation complies with all codes required by the local jurisdiction.



## Certifications, Permits, and Codes

Your Capstone MicroTurbine is designed and manufactured in accordance with a variety of national and international standards.

The Capstone MicroTurbine operates on approved gaseous fuels; thus installation frequently requires one or more permits from local regulatory agencies.

It is not practical to list in the User's Manual the requirements of each authority having jurisdiction and how the Capstone MicroTurbine meets those requirements. For certification data, such as weights, dimensions, required clearances, noise levels, and the Capstone MicroTurbine Compliance List, please contact your Capstone Authorized Service Provider.

## Document Overview

This document provides the data necessary for the user to operate and maintain the Capstone MicroTurbine. Basic troubleshooting is included in this manual, but only Capstone Authorized Service Providers are permitted to perform detailed troubleshooting and repair of the equipment.

For detailed technical data, or for service to the MicroTurbine, contact your Capstone Authorized Service Provider.

## MicroTurbine Introduction

The Capstone MicroTurbine is an adaptable, low-emission, and low maintenance power generation system. A turbine-driven high-speed generator is coupled with digital power electronics to produce high quality electrical power.

The Capstone MicroTurbine is a versatile power generation system suitable for a wide range of applications. Capstone's proprietary design allows users to optimize energy costs while operating in parallel with an electric utility grid. The MicroTurbine can provide prime power generation where the electric utility grid is not readily available or where service is unreliable.

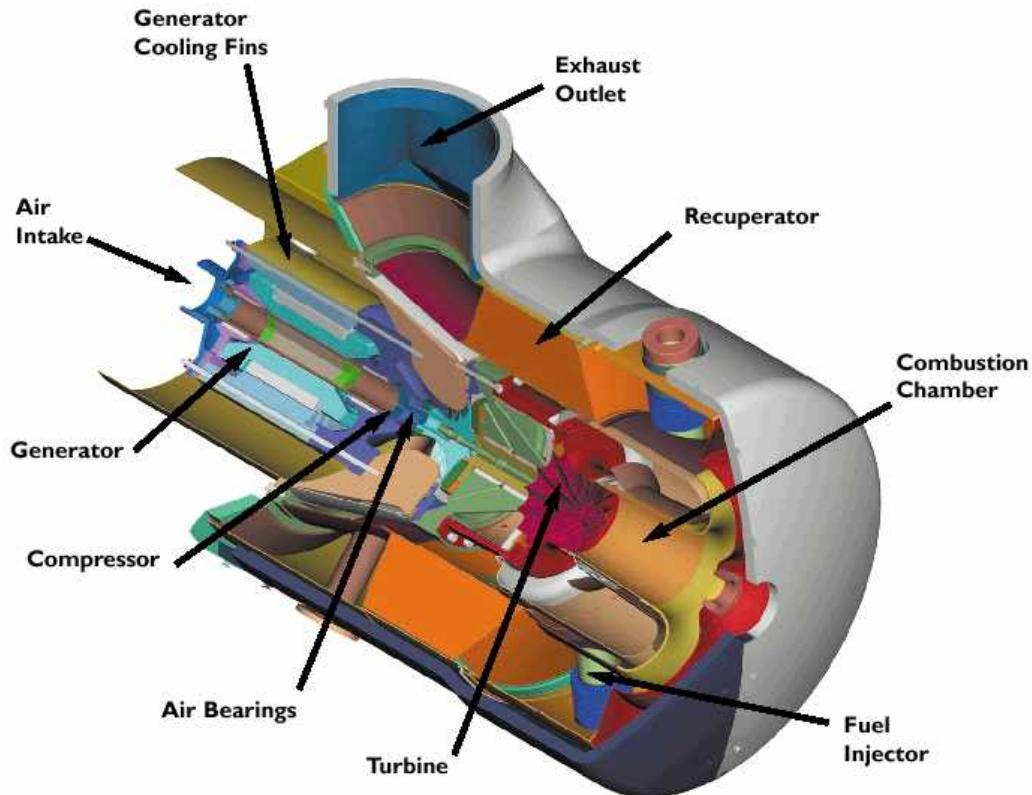
The Alternating Current (AC) electrical power output from the MicroTurbine can be paralleled with an electric utility grid or with another generation source. The MicroTurbine can act as a Stand Alone generator for standby, backup, or remote off-grid power. Multiple systems can be combined and controlled as a single larger power source, called a MultiPac.

The MicroTurbine can efficiently use a wide range of approved hydrocarbon-based gaseous fuels.

The MicroTurbine produces dry, oxygen-rich exhaust with ultra-low emissions. Utilizing both the generated electric power and the exhaust heat can provide even greater energy cost savings.

## Key Mechanical Components

The key mechanical components that make up the Capstone MicroTurbine are shown in the following illustration.



**Typical Capstone MicroTurbine Engine**

## Main Features

The various features of the Capstone MicroTurbine are listed below:

- State-of-the-art Digital Power Controller with built-in protective relay functions provides two output choices:
  - Built-in synchronous AC
  - Stand Alone AC output (optional)
- Patented air bearings eliminate the need for oil or other liquid lubricants.
- Air-cooled design of the entire system (turbine and controller) eliminates the need for liquid coolants.
- Only one moving part. No gears, belts, or turbine-driven accessories.
- Advanced combustion control eliminates the need for ceramics or for other costly materials or for catalytic combustion, and provides ultra-low emissions.
- The integral annular recuperator (heat exchanger) doubles thermal efficiency.
- Digital control technology facilitates advanced control or Ethernet monitoring, and diagnostic capabilities, both on-board and remotely.

## MicroTurbine Engine

The MicroTurbine engine is a combustion turbine that includes a compressor, combustor, turbine, generator, and a recuperator. The rotating components are mounted on a single shaft supported by patented air bearings and spin at up to 96,000 RPM. The permanent magnet generator is cooled by the airflow into the MicroTurbine. The output of the generator is variable voltage, variable frequency AC. The generator is used as a motor during start-up and cooldown cycles.

## Controller

The digital power electronics control the MicroTurbine system operation and all subsystem operations. The digital power electronics change the variable frequency AC power from the generator to DC voltage, and then to constant frequency AC current.

During start up, the digital power electronics operate as a variable frequency drive, and motors the generator until the MicroTurbine has reached ignition and power is available from the MicroTurbine. The digital power electronics again operate as a drive during cooldown to remove heat stored in the recuperator and within the MicroTurbine engine in order to protect the system components.

## Air Bearings

The MicroTurbine utilizes gas foil bearings (air bearings) for high-reliability, low maintenance, and safe operation. This allows fewer parts and the absence of any liquid lubrication to support the rotating group. When the MicroTurbine is in operation, a gas film separates the shaft from the bearings and protects them from wear.

## Fuel System

The MicroTurbine can efficiently use a wide range of approved hydrocarbon-based gaseous fuels, depending on the model. The MicroTurbine includes an integral fuel delivery and control system. The standard system is designed for pressurized hydrocarbon-based gaseous fuels. Other models are available for low-pressure gaseous fuels, gaseous fuels with lower heat content, gaseous fuels with corrosive components, and biogas (landfill and digester gas) fuels. Contact your Capstone Authorized Service Provider for data on approved fuels and performance specifications.

## Emissions

The Capstone MicroTurbine is designed to produce very clean emissions. The exhaust is clean and oxygen rich (approximately 18% O<sub>2</sub>) with very low levels of air pollutants. Like all fuel combustion technology, the MicroTurbine can produce dangerous emissions (like nitrogen dioxide and carbon monoxide) from the fuel combustion process. The MicroTurbine has ultra low nitrogen dioxide (NO<sub>2</sub>) and carbon monoxide (CO) emission levels.

## Enclosure

The MicroTurbine standard enclosure is designed for indoor and outdoor use, and is certified to NEMA 3R - rainproof.

Capstone components for Original Equipment Manufacturer (OEM) use can be provided with or without a mounting frame.

## Stand Alone Option

A Stand Alone or "Dual Mode" option is available for the MicroTurbine, which includes a large battery pack used for unassisted start and for transient electrical load management. The Stand Alone option includes a power converter and battery management system, which keeps the battery optimally charged. The battery is a lead-acid type and completely sealed.

When equipped with the Stand Alone option, the system can power connected loads at user-selected voltage and frequency setpoints. It can power remote facilities such as construction sites, oil fields, offshore platforms, and other locations where the electric utility grid is not available.

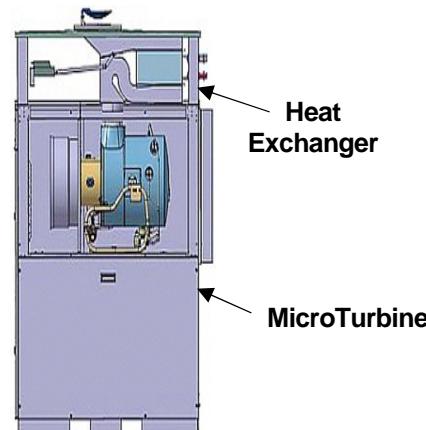
## Distributed Generation

The MicroTurbine produces synchronous current when connected to an electric utility grid. It allows electric utilities to expand power generation capacity in small increments, to optimize current infrastructure, and reduce or delay the need to develop, fund, and build new transmission and distribution lines.

## Integrated Combined Heating and Power (ICHP) Option

The Integrated Combined Heating and Power (ICHP) option allows the user to realize the benefits of usable electrical and thermal power from a single fuel source. The electricity provides on-site power generation for baseload, peak shaving and capacity addition, in conjunction with local utility power. The heat offsets or replaces local thermal loads such as space heating, pool heating and industrial process hot water.

The major system components are a Capstone model C65 high-pressure natural gas MicroTurbine, an exhaust heat recovery unit, and an exhaust diverter to allow full or partial recovery of exhaust energy. The system includes microprocessor control with input/output functions to allow application in a wide variety of heat recovery uses. The system allows a user to realize high total system efficiency with respect to incoming fuel energy, providing economical operation and operational flexibility.



## Offshore Option

The offshore option contains a stainless steel pressurized enclosure, which houses the MicroTurbine system, and is certified for Class I, Division 2 (CID2), or Class I, Zone 2 coastal marine environments. The CID2 option utilizes an integrated blower assembly to draw inlet air from a non-hazardous location. The CID2 option is available as a Dual Mode product.

## Operational Features

Operational features of the MicroTurbine are presented in the following paragraphs.

### Peak Shaving

The MicroTurbine can augment utility supply during peak load periods, thus increasing power reliability and reducing or eliminating peak demand charges.

### Combined Peak Shaving and Standby

The MicroTurbine can be used for both Grid Connect power and Stand Alone power for protected loads, and can be programmed to switch automatically (with the Dual Mode Controller accessory) upon loss/restoration of electric utility grid power. The MicroTurbine, with its low emissions, low maintenance requirements, and high reliability is well suited for combination peak-shaving and standby power applications.

### MultiPac Power

Capstone MicroTurbines can be installed in groups of up to 20 units (up to 30 units with the optional Capstone Advanced Power Server (APS)) and will operate as a single power generation source. This MultiPac capability features a single control point and synchronous voltage and frequency output for all units. Individual MicroTurbines share power, current, and load on both a dynamic and steady state basis.

### Resource Recovery

Capstone MicroTurbine models are available that use methane-based oilfield flare casing gas or low-energy landfill/digester gas as fuel sources. C65 models are available that can accept Sour Gas with up to 5000 ppm Hydrogen Sulfide (H<sub>2</sub>S) content. This application helps eliminate pollution and provides economical power for on-site use as a by-product.

### ICHP Electrical and Thermal Recovery

The dry, oxygen-rich exhaust from the MicroTurbine can also be used for direct heat or as an air pre-heater for downstream burners. The usable electrical and thermal power allows commercial businesses to offset or replace local thermal loads such as domestic hot water, space heating, pool heating, and industrial hot water. In addition, the oxygen-rich exhaust together with ultra-low emissions makes the direct exhaust applicable for some food processing and greenhouse uses, such as heating, cooling (by absorption), dehumidifying, baking, or drying.

## OEM Applications

The MicroTurbine core technology can be integrated into a wide variety of products and systems. Uninterruptible power supplies, all-in-one combined heat and power systems, and welding machines are just a few examples of original equipment manufacturer applications.

## Output Measurements

The measurements presented in this document are in metric units (with U.S. standard units in parentheses). Refer to the sections below for more data.

### ISO Conditions

Combustion turbine powered devices (including the Capstone MicroTurbine) are typically rated at 15 °C (59 °F) at sea level, or 1 atmosphere (1 atm) which is 760 mm Hg (14.696 psia) and identified as International Standardization Organization (ISO) conditions. For a complete definition of ISO testing conditions, refer to ISO 3977-2.

### Pressure

Pressure figures assume gauge pressure, or 1 standard atmosphere (1 atm) 760 mm Hg (14.696 psia) less than absolute pressure, unless otherwise indicated.

### Volume

Fuel gas and exhaust gas volumetric measurements are listed in normalized cubic meters (Nm<sup>3</sup>) and standard cubic feet (scf). These volumes are defined at 1 atm (760 mm Hg, 14.696 psia) and 15.6 °C (60 °F).

### Heating Values

Heat contents and heat rates will be found in either Lower Heating Value (LHV) (dry) or Higher Heating Value (HHV), depending upon the application. Capstone calculates heating values at 1 atmosphere (atm) and 15.6 °C (60 °F), according to ASTM D3588.

### MicroTurbine Performance

The MicroTurbine electrical output capability is reduced when operating in higher ambient temperatures or elevations, and by intake or exhaust restrictions. Contact your Capstone Authorized Service Provider for data on performance specifications.

### Grid Connect Output

The MicroTurbine electrical output in Grid Connect mode is 3-phase, 400 to 480 VAC and 45 to 65 Hz (both voltage and frequency are determined by the electric utility grid). Allowable connection types include:

- 4-wire Wye
- 3-wire Wye with neutral grounding resistor

## Stand Alone Output

When equipped with the Stand Alone option, the electrical output is user adjustable from 150 to 480 Volts AC and from 10 to 60 Hz.

The maximum power need not be balanced. Loads can be connected 3 phases or single phase and phase-to-phase or phase-to-neutral, so long as the current limits are respected. A Ramp Start feature can assist in starting loads with large in-rush currents.

## Power Quality

The MicroTurbine output conforms to IEEE 519-1992, IEEE Recommended Practices, and Requirements for Harmonic Control in Electrical Power Systems.

## Heat Output

The recuperated MicroTurbine can produce up to 612,000 kJ (580,000 Btu) per hour of clean, usable exhaust heat in the range of 260 to 330° C (500 to 630° F).

The MicroTurbine exhaust stream is 203 mm (8 in) in diameter, flowing up to 28 Nm<sup>3</sup> (900 scf) per minute.

Contact your Capstone Authorized Service Provider for data on heat output performance for specific system variations and/or ambient conditions.

# Operating the MicroTurbine

Typical operation of the MicroTurbine is presented in the following paragraphs.

## Basic MicroTurbine (MT) Operation

This section details basic system operation and explains how to use the MicroTurbine.

### Routine Operation

Most MT applications require no regular interaction with an operator during normal operation. Built-in dispatch features include peak shaving with local or remote control, external switch control, programmable scheduling, automatic restart, and automatic loading.

Offshore applications with the pressurized enclosure (Class I, Division 2 option) utilize a Programmable Logic Controller (PLC) unit to monitor external inputs such as gas detection and pressure sensing and intelligently control normal operation. All built-in MicroTurbine dispatch modes remain the same, except for auto restart functionality, which is unavailable.

## Communications

There are two ways for the user to communicate with the MicroTurbine, either (1) via manual operation of the Display Panel, or (2) via digital communications through the User Interface Port (UIP) or Maintenance Interface Port (MIP). Details of Display Panel operation are described in a later section.

A PC may be connected to the User Interface Port directly (with an RS-232 null modem cable or using a serial – to – Ethernet converter) or via a phone line and optional modem. Communication is then possible by use of the optional Capstone Remote Monitoring Software (CRMS) on the PC, or other program that uses Capstone's open communication protocol. The Capstone Service Network (CSN) is an optional remote communication system using an internet connection through a secure Virtual Private Network (VPN), which also can be used in place of CRMS as a real time selectable alternate.

The set-up, control, and basic performance of the MicroTurbine can be monitored and adjusted through the User Interface Port.

Primary user communications include:

- Start and stop functions
- Adjustment of power output
- Storage and display of operation history
- The configuration of operational parameters
- Battery management functions

## Routine Operation Data

The Display Panel (or a computer connected directly or via modem) can be used to monitor many operational parameters during system operation. Only some of the routine operation and performance data items available for monitoring are listed below:

- Power Output (in kilowatts, or kW)
- Turbine Speed (in revolutions per minute, or RPM)
- Turbine Exit Temperature (in °C or °F)
- Phase Voltages (in Volts) and Currents (in Amperes)

## Control Device Authority and Priority

A PC connected to the User or Maintenance Interface Ports can function as a control device for the MT. The Capstone Service Network (CSN) is also a control/monitor medium, using a PC interfacing the web or at the MT User Interface Port. A PC can view system data at any time, but only one device can control the MT operation (that is, providing start/stop command or changes to power demand).

The Display Panel has default control authority to issue operational commands to the MT. The user can start and stop the MT without logging on to the system (that is, no password is required). All other system adjustments require the user to log on to the system with the user password.

The User Interface Port will take control when a password is entered either from the Capstone Remote Monitoring Software or other software using the Capstone open communication protocol.

All system commands via the User Interface Port, such as start, stop, and adjustment of Power Demands, require entry of a user password. When the User Interface Port has control, the Display Panel does not have control and can only be used to view information. The system automatically cancels a log on after five minutes of inactivity.

### Start-up

A Start command can be issued from the Display Panel or remotely via CRMS software/PC interface, or Capstone Service Network (CSN). When the command has been issued, the generator operates as a motor to bring the MT up to ignition speed, at which point fuel is introduced into the combustion chamber and ignited. When the Turbine Exit Temperature (TET) sensors detect an increase in temperature, the system is declared lit, and the MT accelerates to full load.

The start-up process from a cold start to full load requires up to two minutes. For offshore applications with the pressurized enclosure (Class I, Division 2 option), this process may increase to five minutes, due to an air purge cycle. Also, the MicroTurbine system can only be started via the PLC controlling the pressurization system.

### Shutdown

When the MT is issued a Stop command, power output is reduced, followed by a period that the MT is motored at nominal speed to remove heat stored in the recuperator and MT engine in order to protect the system components.

The overall cooldown period is up to ten minutes, but is affected by MicroTurbine model and temperature at shutdown. A restart may be attempted at any time, and a start will occur after completion of the initial cooldown period. Auto Restart is not available for offshore systems with Class I, Division 2 operation.

If the Stand Alone battery requires a recharge (after a stop command is issued), the MicroTurbine will continue to operate with fuel in order to recharge the battery. The MT will enter the cool down period after the battery has reached a 90 to 95% state of charge. The battery can require as long as 20 minutes to recharge after a stop command has been issued before entering cooldown. This will be followed by a cooldown period of up to 10 minutes.

### Emergency Stop (E-Stop)

The optional Emergency Stop (E-Stop) kit is designed to allow for the safe and immediate shut down of the MicroTurbine in the event of an emergency. Activation of the E-Stop immediately shuts off fuel and electrical output. This will cause the compressor bypass valve to open, vent the compressed air out of the MT, and the turbine will coast to a stop.

After an emergency stop, the power to the MT must be turned off for 30 seconds before a restart can be attempted. Emergency stops should **NEVER** be used for routine shutdowns. Emergency stops increase stress on the system components and will result in reduced service life of the MicroTurbine.

<b>CAUTION</b>	Repeated use of the optional Emergency Stop switch will result in damage to the MicroTurbine. Use only in emergency situations.
----------------	---

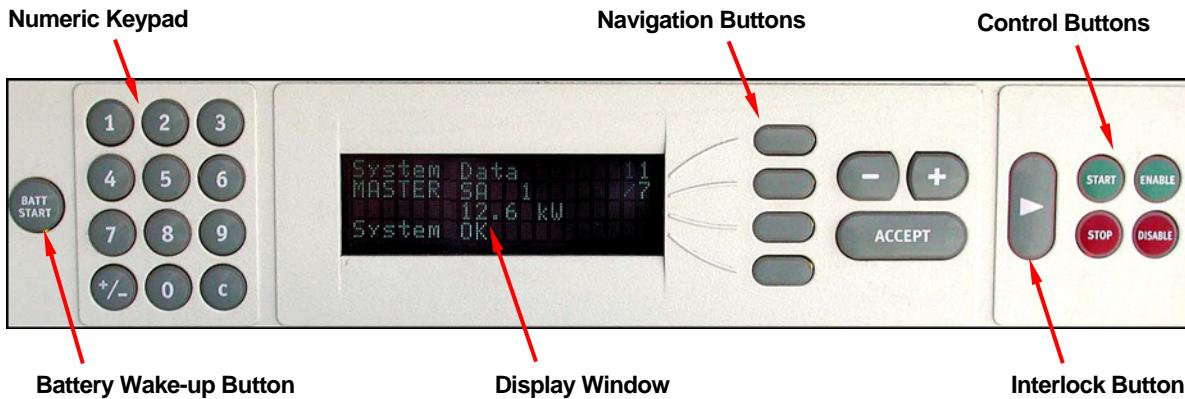
Also, after an emergency stop, you may want to close the external fuel isolation valve to shut off any additional fuel flow into the MT. The external fuel isolation valve must be returned to the open position before a restart of the MT is attempted.

## Restart

The MicroTurbine system can normally be restarted after a shutdown, while the battery recharges, or during the cool down period before the speed of the MT reaches zero. This allows for faster power output and helps to eliminate wear on the bearings.

## Using the Display Panel

Use of the Display Panel is described in the following paragraphs.



## Display Panel and Functions

The Display Panel is located on the front of the package above the engine air inlet, and is used to control MT operation and access data stored within the system. The Display Panel includes a keypad, a display window, navigation buttons, and system control buttons. The paragraphs below describe Display Panel operation.

For offshore applications with the pressurized enclosure (Class I, Division 2 option), Display Panel screen information is visible through a see-thru plastic window. However, access to the panel navigation buttons and numeric keypad should **only** be attempted during maintenance operations, and **only** if the area has been tested to be free of flammable gases.

### Display Panel Areas

The **BATT START** button, at the far left of the Display Panel, is used to wake a Stand Alone system from sleep mode (see Waking a Stand Alone MicroTurbine on page 42).

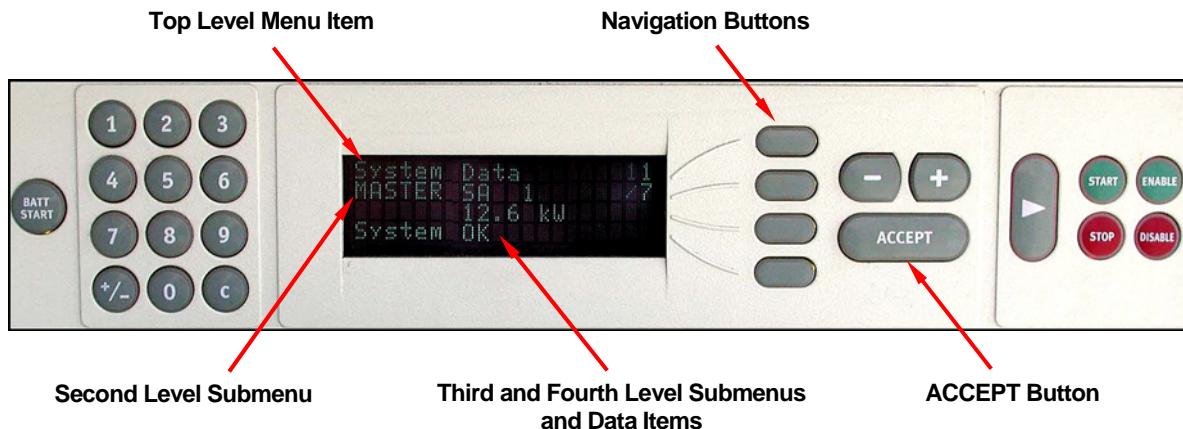
The **Numeric Keypad**, located to the left of the Display Window, is for data input. The system accepts data input only on specific screens, and the input line must be selected, indicated by the flashing line. Data input from the Numeric Keypad requires logging-on with a password (see Logging On with a Password on page 22).

The **Display Window** is in the center of the Display Panel. The Display Window can display four lines of twenty characters, each of which indicate menu hierarchy position, data display, and data input.

The **Navigation Buttons** are located to the right of the Display Window, and consist of four buttons arranged vertically, each with a line to its left indicating a line of data in the Display Window. These four buttons, plus the buttons just to their right labeled (-), (+), and ACCEPT, are the navigation buttons; they are used for selecting various display screens or data items.

## Menu Navigation

Movement around the top-level menu screens can be accomplished by use of the Navigation Buttons. The top line of the display always shows the name of the current top-level menu. See and refer to the following panel and display layout.



## Display Panel and Navigation Functions

To move around the top-level menus, press the topmost of the four line Navigation Buttons. The menu position indicator numbers at the right end of the top line will flash. When the numbers are flashing, press the (-) or (+) buttons to move around the menus.

Each of the top-level menu screens has a number of submenus. The second line in the Display Window shows the current submenu. Movement around the submenus is similar to the top-level menus except you must press the second line Navigation Button to select line two of the display. When the numbers are flashing, press the (-) or (+) buttons to move around the submenus.

When you reach the desired menu, press the ACCEPT button to choose the menu, or wait 20 seconds for the system to automatically accept the menu selected.

The third and fourth levels display the selected performance data or allow input, like passwords or adjustment of power settings. The descriptions of each screen or submenu are grouped according to the top-level menu.

## Display Panel Data Entry

Data input requires selection of the appropriate level with the Navigation Buttons, causing the display line to flash. Enter data using the Numeric Keypad, or scroll through available data entry options with the (-) or (+) buttons and press the ACCEPT button when finished. To make changes to any system set-up or operational mode requires the entry of a user password. Numeric entries can be cancelled by use of the (-) button.

## Logging On with a Password

To enter commands from some of the Display Panel menus, the user must log on with a valid password (the description of the various menus on the following pages includes whether logging on with a password is required).

<b>NOTE</b>	The default user password (at the Display Panel) is set to <b>87712370</b> . In the event of a lost user password, your Capstone Authorized Service Provider can reset the user password to this default.
-------------	--

To log on with a password, follow these steps:

1. At the top-level System Data Menu, push the second level Navigation Button and the (-) or (+) buttons until you come to the Enter Password submenu.
2. Select the third level Navigation Button (the display indicates “\*\*\*\*\*”). Enter the current password (see the above notes).
  - Note that the display of \*\*\*\*\* becomes ----- as you enter the password.
3. Press the ACCEPT Button. The display will indicate “PROTECTED LEVEL SET”.
4. You are now logged into the system.

Not all data items can be modified at the user password level.

## Changing the Password

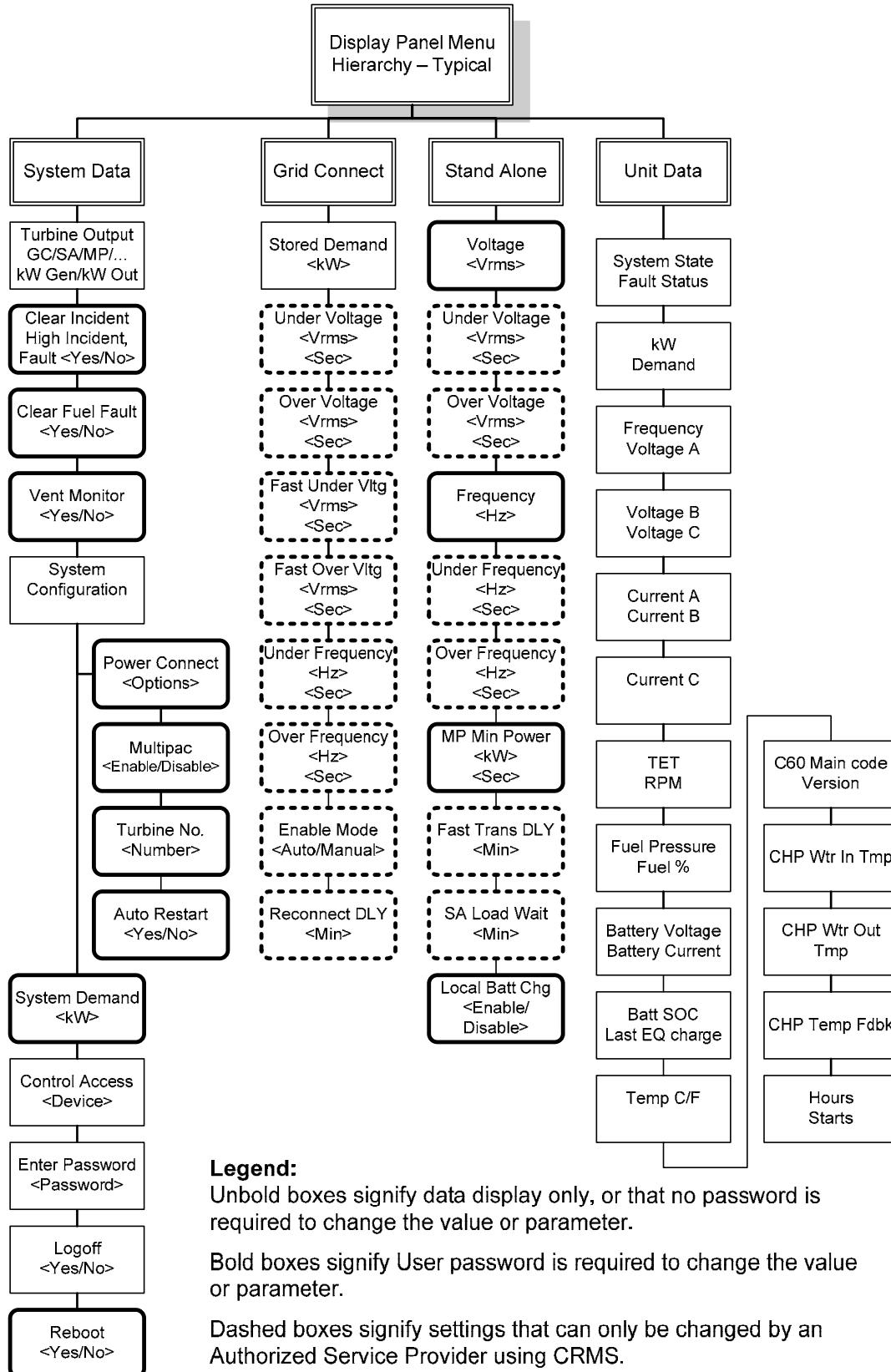
A user can change the user password at any time using the following steps

1. The user must be logged-in (with a password) to change the password.
2. Go to the top-level **System Data** menu, push the second level Navigation Button and the (-) or (+) buttons until you come to the User Password submenu.
3. Select third level Navigation Button (the display indicates \*\*\*\*\***Change**). Enter the new password.
4. Press the ACCEPT button. A confirmation message will be posted that states the password needs to be verified.
5. Press the fourth level Navigation Button. Verify the Password on the fourth level (the display indicates \*\*\*\*\***Verify**). Re-enter the “new” password to verify.
6. Press the ACCEPT button. A confirmation message will be displayed that states the password has been verified.

If the new password is not verified in this manner, the old password will remain in effect.

## Display Panel Menus - Overview

The Display Panel menu hierarchy on the next page presents the typical structure of the system software menus and submenus for the Model C65 MicroTurbine with software version 5.XX. These menus and submenus are also detailed in text following the menu hierarchy chart.



### Display Panel Menu Reflecting Function Hierarchy

## System Data Menu

**NOTE**

The user is able to view the data on various screens of the System Data Menu without logging on. Some of the settings require logging on with a user password.

On power-up, the Display Panel defaults to the top-level System Data menu. The System Data menu displays the total output for a system of 1 to 20 MicroTurbines (up to 30 MicroTurbines with the optional Advanced Power Server) along with other system states.

System Data submenus are detailed below with a sample of the actual display for each submenu. The same applies for the other top level menus, as applicable.

**NOTE**

In the following submenus, the first line always displays System Data menu.

### Turbine Output Submenu

```
System Data      1/4
SINGLE GC OK 1 1/10
      68.4 kW Gen
      65.0 kW Out
```

The second line shows configuration information including whether it is currently configured for GC (Grid Connect) or SA (Stand Alone), whether it is a Single unit, a MultiPac (MP) unit, or the Master of a MultiPac system, and the MicroTurbine number. This submenu also gives individual generator output as <kW Gen> on the third line and the total output of the system in kilowatts (kW Out) on the fourth line. If a MultiPac, then total aggregate MP system output is indicated.

### Clear Incident Submenu

```
System Data      1/4
Clear Incident  2/10
System OK
NO
```

The Clear Incident submenu attempts to clear the highest-level fault and to return the system to standby. The <High Incident, Fault> line displays the system highest fault type and the associated identification number of the fault currently reported by the system. If the fault can be cleared, the fault # line will be updated with the next highest active fault, or System OK if all faults were cleared. If the same fault remains, the fault cannot be cleared. Note that the user must be logged in with the current password to clear the faults.

### Clear Fuel Fault Submenu

```
System Data      1/4
Clear Fuel Fault 3/10
NO
```

The Clear Fuel Fault clears a fault originated by the fuel vent system (if installed) which causes a MT shutdown. The user must bring the MT back up (power up), then activate the 'Clear Fuel Fault' which clears the fault. Then the user must do a Reboot. The cause of this fault may be a leak in the system, so troubleshooting and leak detection must be done immediately. Note that the user must be logged in with the current password to clear the faults.

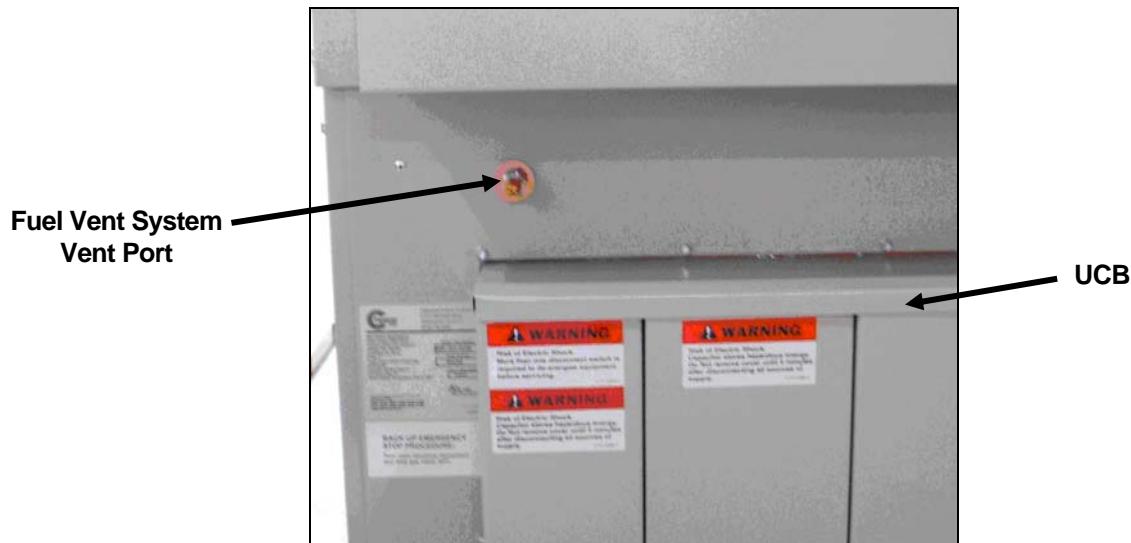
### Vent Monitor Submenu

```
System Data      1/4
Vent Monitor     4/10
YES
```

Some C65 MicroTurbines include a fuel vent system that will exhaust gaseous fuel outside the MT enclosure and activate an automatic shutdown in case of a fuel system leak. This setting should be configured properly at the factory, and should therefore not require user configuration. If you are unsure whether your MT includes this fuel vent system, refer to the figure below. If your MT has a fuel screen installed as shown, then a fuel vent system is installed. If there is no screen or a plug covering the opening used for this vent, then your MT does not have this fuel vent system installed.

If no Vent system is installed in your MT, choose <NO>. If the fuel vent system exists in your MT, choose <YES >.

<b>NOTE</b>	If the fuel vent system is installed, any leaks in the Woodward valve area will be detected by the vent system and a MT shutdown will be initiated. If no such vent system is installed, you may contact your Authorized Service Provider for information regarding addition of this venting capability.
-------------	--



**MicroTurbine Back View**

<b>NOTE</b>	Fuel Vent System Vent Port: If port is present as shown, vent system is installed. If there is no screen or only a cover is at that location, no vent system is installed.
-------------	--

## System Configuration Submenu

The System Configuration submenu contains system settings and allows the user to adjust the third level data, as detailed below:

### Power Connect Submenu

```
System Data      1/4
System Config   5/10
Power Connect   1/4
Dual Mode
```

The Power Connect submenu allows the user to change the operating mode of the MicroTurbine. Note that the user must be logged in with the current password to change the operating mode.

- Invalid State (Initial Factory Setting)
- Stand Alone
- Grid Connect
- Dual Mode

<b>NOTE</b>	The initial Factory Setting of "INVALID" is intended to ensure the true Power Connect option is set to match your specific application.
-------------	---

### **MultiPac Submenu**

```
System Data      1/4
System Config   5/10
MultiPac        2/4
ENABLE
```

The MultiPac submenu allows the user to remove or add a MicroTurbine to a MultiPac. This allows maintenance of a MicroTurbine unit in a MultiPac without having to shut down all MicroTurbines in the system. Note that the user must be logged in with the current password to change this setting.

### **Turbine Number Submenu**

```
System Data      1/4
System Config   5/10
Turbine Number   3/4
1
```

The main controller MicroTurbine in a MultiPac system is designated as the "Master", and must be assigned as number "1". Other MicroTurbines may be assigned in any order in a MultiPac system, however, each MT must have a unique turbine number. Note that the user must be logged in with the current password to change the turbine number.

### **Auto Restart Submenu**

```
System Data      1/4
System Config   5/10
Auto Restart    4/4
NO
```

The Auto Restart submenu enables or disables the system's ability to automatically attempt to restart after an incident driven shutdown. Note that the user must be logged in with the current password to change this setting.

### **System Demand Submenu**

```
System Data      1/4
System Demand   6/10
          0.0 kW
```

The System Demand submenu allows the user to set the system power demand in kW. Note that the user must be logged in with the current password to change system demand.

### Control Access Submenu

```
System Data      1/4
Control Access  7/10
Maintenance Port
```

The Control Access submenu displays which communication device currently has control authority for changing settings of the MicroTurbine.

- Display Panel
- User Port
- Maintenance Port

### Enter Password Submenu

```
System Data      1/4
Enter Password  8/10
*****
```

The Enter Password submenu allows the user to logon and access the MicroTurbine controls. The factory default User-level password is 87712370. Refer to the previous section on passwords for more details on entering and changing passwords.

### Logoff Submenu

```
System Data      1/4
Logoff          9/10
NO
```

The Logoff submenu allows the user to logoff and prevents further access to the MicroTurbine controls. Note that the system will automatically logoff if there is no user interaction with the Display Panel for more than four minutes.

### Reboot Submenu

```
System Data      1/4
Reboot          10/10
NO
```

The Reboot submenu allows the user to reboot the system.

If Yes is selected, the system will reboot immediately. Note that the user must be logged in with the current password to reboot the system.

### Grid Connect Menu

The top-level Grid Connect menu establishes operation parameters for the Grid Connect mode. This menu is applicable only when the MicroTurbine operates in Grid Connect mode. The Grid Connect Protective Relay settings are established here.

Refer to the following reference documents as required:

- Grid Connect Operation Technical Reference (410052)
- Model C60/C65 Electrical Technical Reference (410001)
- Protective Relay Functions (410033)

The Grid Connect submenus are detailed below:

<b>NOTE</b>	In the following submenus, the first line always displays the Grid Connect top level menu.
-------------	--

### Stored Demand Submenu

```
Grid Connect      2/4
Stored Demand    1/9
65.0 kW
```

The Stored Demand submenu allows entry of the power output demand level in kilowatts. A password is not required to adjust this parameter from the Display Panel. Power output is adjustable from 0.0 to 2,000,000.0 kW to allow for the use of the MultiPac configuration.

<b>WARNING</b>	Do not attempt to change any Grid Connect Protective Relay functions. Injury to personnel and/or damage to equipment can occur. Contact your Capstone Authorized Service Provider for additional information.
----------------	---

<b>NOTE</b>	The primary Grid Connect Protective Relay function is to ensure that the MicroTurbine does not energize utility wires de-energized by the utility.
-------------	--

<b>NOTE</b>	All of the following Protective Relay settings can only be changed by an Authorized Service Provider using CRMS.
-------------	--

### Under Voltage Submenu

```
Grid Connect      2/4
Under Voltage    2/9
      422 Vrms
      2.00 Sec
```

The Under Voltage submenu shows the line-to-line voltage and associated delay time. If the RMS voltage between any phases falls below this setting, the delay timer is started. If the voltage has not recovered at the end of this time, the system will shut down. This is adjustable from 352 up to the Over Voltage setpoint in 1 volt increments. Initial Factory Setting is 422 VAC line-to-line.

Under Voltage Delay establishes the time allowed for any phase voltage to fall below the Under Voltage limit. The delay is adjustable from 0.01 up to 10 seconds in 0.01 second increments. Initial Factory Setting is 2.0 seconds.

### Over Voltage Submenu

```
Grid Connect      2/4
Over Voltage     3/9
      528 Vrms
      1.00 Sec
```

The Over Voltage submenu shows the line-to-line voltage and associated delay time. If the RMS voltage between any phases rises above this setting the delay timer is started. If the voltage has not subsided by the end of this time, the system will shut down. This is adjustable from 528 down to the Under Voltage setpoint in 1 volt increments. Initial Factory Setting is 528 Volts.

Over Voltage Delay establishes the time allowed for any phase voltage to rise above the Over Voltage limit. The delay is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 1.0 second.

### Fast Under Voltage Submenu

```
Grid Connect      2/4
FastUnder V1ts   4/9
      240 Vrms
      0.16 Sec
```

The Fast Under Voltage submenu shows the line-to-line voltage and associated delay time. The system will cease power export to the grid within 1 msec if any phase RMS voltage drops below the Fast Under Voltage setting for the set time delay. If the grid voltage re-stabilizes within 1 second of the initial under voltage, then the system will resume power output; otherwise, the system will shut down. The Fast Under Voltage at which this sequence will be triggered is adjustable here from 0 VAC up to the Under Voltage setpoint. The delay time is adjustable from .03 to 1.00 second in .01 second increments. Initial Factory Settings are 240 V line-to-line and .16 second delay.

### Fast Over Voltage Submenu

```
Grid Connect      2/4
FastOver V1ts    5/9
      576 Vrms
      0.16 Sec
```

The Fast Over Voltage submenu shows the line-to-line voltage and associated delay time. The system will cease power export to the grid within 1 msec if any phase RMS voltage exceeds the Fast Over Volts setting for the set time delay. If the grid voltage re-stabilizes within 1 second of the initial over voltage, then the system will resume power export; otherwise, the system will shut down. The Fast Over Voltage at which this sequence will be triggered is adjustable here from the Over Voltage up to 634 volts. The delay time is adjustable from .03 to 1.00 second in .01 second increments. Initial Factory Settings are 576 V line-to-line and .16 second delay.

### Under Frequency Submenu

```
Grid Connect      2/4
Under Frequency  6/9
      59.3 Hz
      0.16 Sec
```

The Under Frequency submenu shows the system under frequency and associated delay time. If the grid frequency falls below this under frequency setpoint for the set delay time, the system will shut down. The frequency is adjustable from 45 Hz up to the Over Frequency setting, in 0.1 Hz increments. Initial Factory Setting is 59.3 Hz.

The Under Frequency Delay is the number of seconds allowed for the Under Frequency condition before the system shuts down. This is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is .16 second.

### Over Frequency Submenu

```
Grid Connect      2/4
Over Frequency    7/9
      60.5 Hz
      0.16 Sec
```

The Over Frequency submenu shows the system over frequency and associated delay time. If the grid frequency exceeds this over frequency setpoint for the set delay time, the system will shut down. The frequency is adjustable from the Under Frequency setting to 65, in 0.1 Hz increments. Initial Factory Setting is 60.5 Hz.

The Over Frequency Delay is the number of seconds allowed for the Over Frequency condition before the system shuts down. This is adjustable from 0 to 10 in 0.01 second increments. Initial Factory Setting is .16 second.

### Enable Mode Submenu

```
Grid Connect      2/4
Enable Mode       8/9
      AUTO
```

The Enable Mode submenu applies only to Dual Mode configured systems. The display shows whether the system will transition back to Grid Connect Mode manually (manual) or automatically (auto) with this setting.

### Reconnect Delay Submenu

```
Grid Connect      2/4
Reconnect DLY     9/9
      5.0 Min
```

The Reconnect Delay submenu applies only to Dual Mode configured systems. After a transition to Stand Alone, the turbine checks that the utility grid voltage is within the protective relay settings for this time limit before reconnecting to the grid. It is the minimum amount of time the system will operate in hot standby mode. Initial Factory Setting is 5 minutes. The timer can be set from 5 to 30 minutes.

## Stand Alone Menu

The top-level Stand Alone menu establishes voltage and frequency output and is applicable only when the MicroTurbine operates in Stand Alone mode. It also establishes the operational limits for voltage and frequency, and the rates at which voltage and frequency are increased to nominal on start up (RampStart). These limits are usually set when the MicroTurbine is commissioned and are not changed once set.

Refer to the following reference documents as required:

- Stand Alone Operation Technical Reference (410053)
- Model C60/C65 Electrical Technical Reference (410001)

The Stand Alone submenus are detailed below:

<b>NOTE</b>	In the following submenus, the first line always displays the Stand Alone top level menu.
-------------	---

### Voltage Submenu

```
Stand Alone      3/4
Voltage        1/10
        480 Vrms
```

The Voltage submenu is used to set the nominal RMS output voltage (line-to-line) in Stand Alone Mode. Voltage is adjustable from 150 to 480 in one-volt increments. Initial Factory Setting is 480 VAC line-to-line. Note that the user must be logged in with the current password to change this voltage setting.

<b>WARNING</b>	Do not attempt to change any Stand Alone Protective Relay functions. Injury to personnel and/or damage to equipment can occur. Contact your Capstone Authorized Service Provider for additional information.
----------------	--

<b>NOTE</b>	All of the following Protective Relay settings can only be changed by an Authorized Service Provider using CRMS.
-------------	--

### Under Voltage Submenu

```
Stand Alone      3/4
Under Voltage   2/10
                  352 Vrms
                  10.00 Sec
```

The Under Voltage submenu shows the line-to-line voltage and associated delay time. If the RMS voltage between any phases falls below this setting, the delay timer is started. If the voltage has not recovered at the end of this delay time, the system will shut down. Voltage is adjustable from 0 up to nominal. Initial Factory Setting is 352 volts.

The Under Voltage Delay establishes the time period allowed for any phase voltage to fall below the Under Voltage limit. The delay is adjustable from 0.01 up to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds.

### Over Voltage Submenu

```
Stand Alone      3/4
Over Voltage    3/10
                  528 Vrms
                  10.00 Sec
```

The Over Voltage submenu shows the line-to-line voltage and associated delay time.

If the RMS voltage between any phases rises above this setting the delay timer is started. If the voltage has not subsided by the end of this time span, the system will shut down. Voltage is adjustable from 528 down to nominal in 1 volt increments. Initial Factory Setting is 528 Volts.

Over Voltage Delay establishes the time span allowed for any phase voltage to rise above the Over Voltage limit. The delay is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds.

### Frequency Submenu

```
Stand Alone      3/4
Frequency      4/10
                  60.0 Hz
```

The Frequency submenu establishes the nominal output frequency. This is adjustable from 45 to 65 in 1-Hz increments. Initial Factory Setting is 60 Hz.

Note that the user must be logged in with the current password to set this frequency.

### Under Frequency Submenu

```
Stand Alone      3/4
Under Frequency 5/10
      45.0 Hz
      10.00 Sec
```

The Under Frequency submenu shows the system under frequency and associated delay time. If the output frequency falls below this under frequency setpoint for the set delay time, the system will shut down. The frequency is adjustable from 45 to the nominal output frequency in 0.1 Hz increments. Initial Factory Setting is 45 Hz.

Under Frequency Delay is the time span allowed for output frequency to fall below Under Frequency (Hz) before the system will shut down. This is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds.

### Over Frequency Submenu

```
Stand Alone      3/4
Over Frequency 6/10
      65.0 Hz
      10.00 Sec
```

The Over Frequency submenu shows the system over frequency and associated delay time. If the output frequency rises above this over frequency setpoint for the set delay time, the system will shut down. The frequency is adjustable from 65 Hz down to the nominal output frequency, in 0.1 Hz increments. Initial Factory Setting is 65 Hz. If the output frequency exceeds the Over Frequency setting for the time delay setting, the system will shut down. The time delay is adjustable from 0.01 to 10 seconds in 0.01 second intervals. Initial Factory Setting is 10 seconds.

### MultiPac Minimum Power Submenu

```
Stand Alone      3/4
MP Min Power    7/10
      30.0 kW
      60 Sec
```

The MultiPac Minimum Power submenu sets the minimum power level that a Stand Alone MultiPac must be able to provide prior to switching onto a load. The kW setting is the minimum value of total power available from the MultiPac MicroTurbines before the Master MicroTurbine commands the MicroTurbine(s) to go into Load State and begins outputting power. This setting ensures that the system has enough power generating capability before power is allowed to be exported to the load and should be set to the maximum expected load. Initial Factory Setting is 0 kW.

The timeout period setting establishes the maximum time to achieve the kW setting before the system shuts down automatically. This timeout setting is adjustable from 60 to 3600 seconds in 1 second intervals. Initial Factory Setting is 60 seconds.

Refer to MultiPac Operation Technical Reference (410054) as required. Note that the user must be logged in with the current password to change these settings.

#### Fast Transfer Delay Submenu

```
Stand Alone      3/4
Fast Trans DLY  8/10
      0.0 Min
```

The Fast Transfer Delay submenu applies only to Dual Mode configured systems. This submenu displays the delay timer for the mode transition, in both directions, during fast transfer. The Initial Factory Setting is 0 minutes. The timer can be set from 0 to 30 minutes. The system will operate in Stand Alone Recharge ("hot standby") state while this timer runs before the transfer is completed.

#### Stand Alone Load Wait Submenu

```
Stand Alone      3/4
SA Load Wait    9/10
      5.0 Min
```

The Stand Alone Load Wait submenu applies only to Dual Mode configured systems. This submenu displays the timer that maintains the system in Stand Alone Load State before the transition back to Grid Connect, after the grid has returned to normal. The timer begins when the utility voltage and frequency are detected to be within the required operating range, and maintains the turbine in the Stand Alone load state until the time has expired. The Initial Factory Setting is 5 minutes. The timer can be set from 5 to 30 minutes.

#### Local Battery Charge Submenu

```
Stand Alone      3/4
Local Batt Chg  10/10
DISABLE
```

The Local Battery Charge submenu controls whether the system begins a battery equalization charge. This can be done when the system is in Grid Connect mode, or in Standby state, or in the Stand Alone Recharge state ("Hot Standby"). Selecting ENABLE will begin the equalization charge, which can last up to 4 hours. Note that the user must be logged in with the current password to change this setting.

## Unit Data Menu

The top-level Unit Data menu displays real-time data for the MicroTurbine. The second and third lines display data for that specific unit.

Data can also be accessed using CRMS.

The Display Panel functions related to Unit Data menu are listed below:

<b>NOTE</b>	In the following submenus, the first line always displays the Unit Data top level menu.
-------------	---

Submenu / Function	Description
System State / Fault Status	System State / Fault Status
kW / Demand	kW Output / kW Demand
Frequency / Voltage A	Output Frequency / Voltage Phase A
Voltage B / Voltage C	Voltage Phase B / Voltage Phase C
Current A / Current B	Current Phase A / Current Phase B
Current C	Current Phase C
TET / RPM	Turbine Exit Temperature / Engine Speed (RPM)
Fuel Pressure / Fuel %	Fuel Pressure / Fuel Percentage
Battery Voltage / Battery Current	Battery Voltage / Battery Current
Batt SOC / Last EQ Charge	Battery State of Charge / Last Equalization Charge Time
Temp C/F	Temperature °C/°F
C60 Main Code / Version	C65 Main Software Version Code
CHP Wtr In Tmp	CHP Water Inlet Temperature
CHP Wtr Out Tmp	CHP Water Outlet Temperature
CHP Temp Fdbk	CHP Temperature Feedback
Hours / Starts	Running Time / Number of Starts

Below is an example display for a MicroTurbine reading the State of Charge (0) with the last equalization charge date.

```
Unit Data      4/4
              0 SOC 10/16
04/07/2007 Last EQ
```

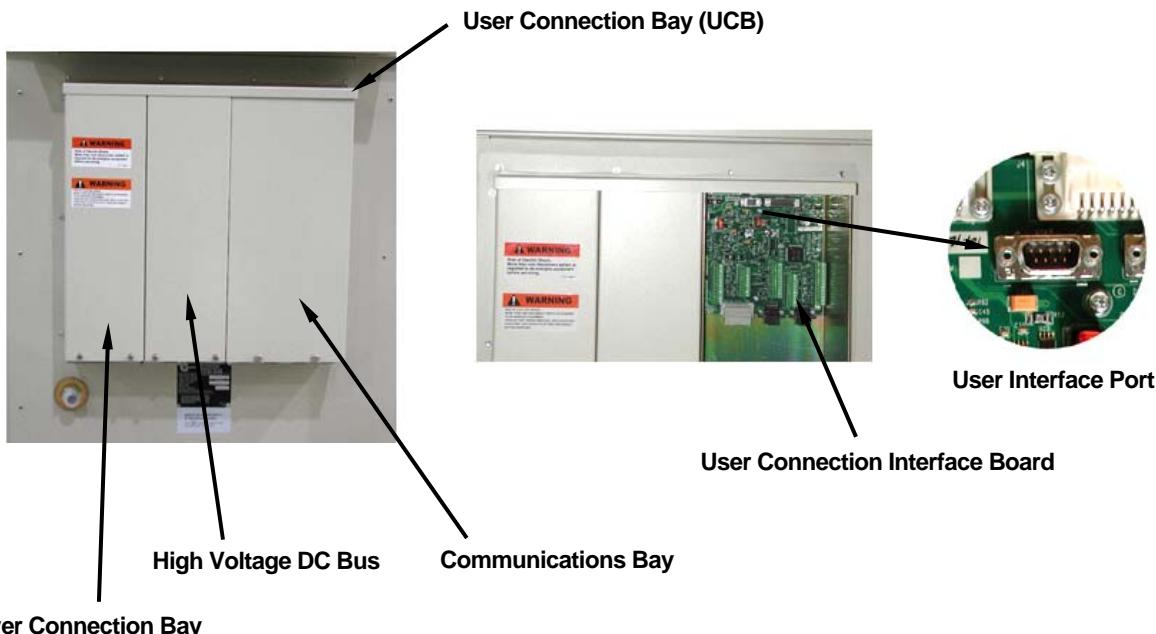
## Using the User Interface Port

The User Interface Port is a DB9 RS-232 serial communications port located on the User Connection Board in the Communications Bay on the back of the MicroTurbine, and is available for remote MT operation.

**WARNING**

The User should NOT open bays other than the Communications Bay within the User Connection Bay (UCB). Potentially lethal voltages exist inside the other bays.

The following figure shows the User Interface Port location.



### MicroTurbine User Connection Bay Designations

You can communicate with the MicroTurbine via the User Interface Port by using a Windows 98/2000/NT or later computer with an RS-232 null modem cable or Serial to Ethernet Converter and Capstone Remote Monitoring Software (CRMS). Optionally, a modem may be connected to the User Interface Port for remote operation via a phone line at a baud rate of up to 56k bps.

**NOTE**

The default User Interface Port user password is set to **USR123P**; the user can change it by using the Capstone Remote Monitoring Software on a computer connected either directly to the User Interface Port or remotely via a modem.

In the event of a lost user password, your Capstone Authorized Service Provider can reset the user password to this default.

## Capstone Remote Monitoring Software

Capstone Remote Monitoring Software (CRMS) is the optional Capstone proprietary software that can operate and control the MicroTurbine from the RS-232 User Interface Port. This allows communication interface devices (a laptop plugged in with a null-modem cable or Serial to Ethernet Converter or a remote computer via a modem) to communicate via the RS-232 port.

CRMS is an easy to use, menu driven Windows-based software for a remote computer to monitor and control the Capstone MicroTurbine. The software can control from 1 to 100 MicroTurbine systems, by direct connection or remotely via a modem. Copies of and licenses for this software are available for purchase from Capstone.

## MicroTurbine Operating Modes

This section explains the different operating modes of the Capstone MicroTurbine and how to issue the applicable commands for each mode.

### Grid Connect Operation

The MicroTurbine in Grid Connect operation allows electric utilities to expand generating capacity in small increments. This optimizes current infrastructure and reduces the need to upgrade specific site capacity and lowers overall costs.

#### Grid Connect Dispatch

Operation of the Capstone MicroTurbine in parallel with an electric utility grid consists only of commanding the system on or off, and commanding an output power level. In most configurations these commands are mostly or entirely automated in various ways termed dispatch modes.

**NOTE**

If Grid Power is removed for any reason, the auto restart dispatch mode can automatically command the system ON when Grid Power is restored.

### Configuring Grid Connect

To configure the MT for Grid Connect operation it is necessary to enable the Grid Connect Interlock and then command the system to Grid Connect mode either through the Display Panel or RS-232 commands using the User Interface Port.

#### Grid Connect Interlock

The Grid Connect Interlock consists of a pair of 5-volt dry circuit contact terminals located on the User Connection Board. A low resistance closed circuit between these terminals permits Grid Connect operation, opening the circuit disallows Grid Connect operation. The terminals are found in the Communications Bay at the rear of the MicroTurbine enclosure. **Your Capstone Authorized Service Provider should make this electrical connection.**

## Grid Connect Mode Enable

To enable the Grid Connect mode, the MicroTurbine must be correctly connected to a suitable live electric utility grid and the Grid Connect Interlock must be closed. **Your Capstone Authorized Service Provider should make this electrical connection.**

To enable the Grid Connect mode from the Display Panel, requires logging on with a password; then navigate to the System Data menu, then to the System Configuration submenu, and then to the Power Connect submenu. Select Grid Connect mode and then press the **ACCEPT** button. If the Grid Connect Interlock is open, the system will accept the command but post a GC Interlock fault, prohibiting a start.

## Starting a Grid Connect System

The MicroTurbine system in Grid Connect mode must be commanded to start. Even if the system is configured for automatic operation, the initial **START** command is required to enable the automatic mode. If the Auto Restart feature is enabled, the **ON** command is stored by the system even through a loss of Grid Power.

To start the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **START** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Start or On to start the system.)

## Stopping a Grid Connect System

The MicroTurbine system can be stopped at any time. In Grid Connect operation, an **OFF** command will override any dispatch mode settings, and is stored by the system.

The shutdown process includes a cool down period, which can last up to 10 minutes, depending on the operating temperature at shutdown. During the cool down cycle, the power output is reduced and fuel supply is off but the MicroTurbine continues to rotate to dissipate excess heat.

A restart can be attempted at any time during a cool down period.

To stop the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **STOP** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Stop or Off to stop the system.)

## Grid Connect Power Demand

In Grid Connect operation, the MicroTurbine system must be commanded to a specific output power level. Each dispatch mode includes a power level setting. Some dispatch modes include automatic output power level changes.

## Stand Alone Operation

Stand Alone operation provides power to remote facilities such as construction sites, oilrigs, or other locations where the electric utility grid is not available.

If the Capstone MicroTurbine is equipped with the Stand Alone option, operation consists of commanding the system on or off, and then enabling or disabling the power output. These commands can be automated.

## Configuring Stand Alone

To configure the MicroTurbine for Stand Alone operation it is necessary to enable the Stand Alone Interlock and then command the system to Stand Alone mode either through the Display Panel or RS-232 commands over the remote communications interface, the User Interface Port.

### Stand Alone Interlock

The Stand Alone Interlock consists of a pair of 5-volt dry circuit contact terminals. A low resistance closed circuit between these terminals permits Stand Alone operation. An opened circuit prevents Stand Alone operation. The terminals are found in the Communications Bay at the rear of the MicroTurbine enclosure. **Your Capstone Authorized Service Provider should make this electrical connection.**

### Stand Alone Mode Enable

To enable Stand Alone mode, the MicroTurbine must be powered on (set the Battery Switch to **ON**) and the Stand Alone Interlock closed. To enable Stand Alone mode from the Display Panel requires logging on with a password; then navigate to the System Data Menu, System Configuration submenu, and the Power Connect submenu. Select Stand Alone mode, then press the **ACCEPT** button. If the Stand Alone Interlock is open, the system will accept the command but post an SA Interlock fault. If no battery is detected, an internal No Battery fault will be reported.

### Stand Alone Battery

The Stand Alone MicroTurbine includes a large battery pack which stores energy for MT startup when disconnected from the electric utility grid, and which provides an electrical buffer for sudden increases or decreases in load during Stand Alone operation. Management of the battery and its state of charge is automatic within the MT. An awareness of these battery management functions will promote an understanding of why the system may appear to behave autonomously. For example, the MicroTurbine will always attempt to fully recharge the battery after a user commanded shut down and before the MicroTurbine enters the cool down state.

### Stand Alone Battery Isolation Switch

The Stand Alone MicroTurbine includes a battery isolation switch to disable the MT for service or transport. The switch is found behind the front door at the bottom front of the enclosure. Set the switch to **ON** for system operation. Be sure to switch the breaker to **OFF** when not operating the system to maximize battery life.

### System Sleep in Stand Alone Mode

Reducing battery draw to near zero during prolonged periods of non-use can extend the MicroTurbine battery charge significantly. This is called Sleep Mode. Sleep Mode is automatic, but the time of inactivity can be adjusted using CRMS. If the battery isolation switch is set to **ON**, and the Display Panel is dark, the system is most likely in Sleep Mode. In Sleep Mode, the battery pack needs to be recharged periodically. Refer to the section on Battery Maintenance for more data on recharging the Battery.

## Waking a Stand Alone MicroTurbine

If the Stand Alone system is in Sleep Mode, pressing the **BATT START** button at the far left of the Display Panel (for less than or equal to 2 seconds) will wake it up. If communicating with the MicroTurbine remotely using a modem connected to the User Interface Port, the modem ring indicator will wake up a sleeping Stand Alone system.

<b>CAUTION</b>	Permanent closure of the battery start contacts (in the following paragraph) will completely discharge the UCB battery. Therefore, the battery start contacts may only be closed for a period of 0.1 to 2.0 seconds.
----------------	--

Alternately, momentarily closing the battery start contacts in the communication bay will wake up the system. This must be a momentary closure of 0.1 to 2.0 seconds only, as permanent closure of these contacts will completely discharge the battery. **Your Capstone Authorized Service Provider should make this electrical connection.**

## Starting a Stand Alone System

The MicroTurbine system in Stand Alone operation must be commanded to start. Even if the system is configured for automatic operation, an initial start command is required to enable the automatic mode. If the Auto Restart feature is enabled, the **ON** command is stored by the system even through a loss of system power.

To start the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **START** button. (If your MT has been configured with a remote start/stop switch, simply set the switch to Start or On to start the system.)

## Enabling Stand Alone Power Output

To enable power output, first start the MicroTurbine, and wait for the engine to warm up and for the base battery state of charge to reach at least 60%. A Not Ready to Load message is displayed. Press and hold the **INTERLOCK** button, and then press the **ENABLE** button.

<b>NOTE</b>	The Enable command can be issued at any time. The system will transition to power output when battery voltage and state of charge are ready.
-------------	--

The Auto Load dispatch mode will automatically issue the Enable command when the system is ready to support the connected loads.

## Stand Alone System Power Level

In Stand Alone mode, the MicroTurbine system will produce (up to its capacity) whatever current is necessary to maintain the commanded voltage and frequency. The output power is determined by the connected load(s).

## Disabling Stand Alone Power Output

To disable power output, press and hold the **INTERLOCK** button, and then press the **DISABLE** button. All power output will immediately cease, but the system will continue operating with fuel.

## Stopping a Stand Alone System

The MicroTurbine system can be stopped at any time.

To stop the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **STOP** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Stop or Off to stop the system.)

A system **OFF** command first disables power output. The system then charges the battery, which can take up to 20 minutes. Finally, the turbine shutdown process includes a cool down period, which can last up to 10 minutes.

## Dual Mode Operation

If the MicroTurbine is equipped with the Stand Alone option and the optional Dual Mode Controller is installed, a setting in the MicroTurbine system software enables the system to reconfigure itself to either Grid Connect or Stand Alone operation mode. This is called Dual Mode.

In the case of grid loss/recovery, MT operation in Dual Mode is identical to the operation in Grid Connect mode or Stand Alone mode. Operation of the Dual Mode feature consists of switching the MT (and protected loads) from Grid Connect operation to Stand Alone operation, or back.

**NOTE**

Note that both the Grid Connect and Stand Alone interlock terminals must be closed for Dual Mode operation.

### Capstone Dual Mode Controller

The Capstone Dual Mode Controller is an optional accessory that enables the MicroTurbine to automatically transition from Grid Connect operation to Stand Alone operation when a utility power outage occurs. During a utility power outage, the MicroTurbine normally operates in Stand Alone mode to provide power to Protected Loads. The Dual Mode Controller isolates the MT and the Protected Loads during Stand Alone operation. When utility power is restored, the Dual Mode Controller automatically returns the MT and the Protected Loads to Grid Connect operation. The Dual Mode Controller also allows the MT to be used as an automatically dispatched standby generator for Protected Loads.

The Dual Mode Controller can:

- Sense the loss of electric utility grid voltage, and then disconnect the MT and its connected (protected) loads from the electric utility grid.
- Start the system and supply Stand Alone power.
- Sense the return of electric utility grid voltage, and then shut down the MT.
- Reconnect the MT and protected loads to the electric utility grid.
- Start the system and supply electric utility grid parallel power.

The MicroTurbine can be configured to automatically start and load itself in either mode.

## Configuring Dual Mode

The MicroTurbine system settings must be established for both Grid Connect parameters and Stand Alone parameters, since the system will be operating in both modes at different times. Contact your Capstone Authorized Service Provider for data on establishment of these parameters.

### Setting the System for Dual Mode Operation

To set the system to Dual Mode, use either the Display Panel or the User Interface Port. If using the Display Panel, you must log on with a password. Navigate to the top-level System Data menu, then the System Configuration submenu, and then the Power Connect submenu, and then select **DUAL MODE** and press the **ACCEPT** button.

### Switching Times for Dual Mode

C65 MicroTurbines with version 5.XX software include the capability for Fast Transfer between Grid Connect and Stand Alone modes. During a transition from Grid Connect and Stand Alone, the protected load will experience less than 10 seconds of power loss. When transferring back from Stand Alone to utility grid power, the protected loads will experience even less duration of power loss, and the MicroTurbine(s) will remain in a Hot Standby condition until the utility grid has remained stable for at least 5 minutes. (this delay time is adjustable from 5 to 30 minutes). The MicroTurbine(s) will then automatically transition back to Grid Connect operation.

## MultiPac Operation

Capstone MicroTurbines may be configured into an array of up to 20 MicroTurbines (up to 30 with the optional Capstone Advanced Power Server (APS)). Such an array will operate as a single power generation source. This MultiPac capability features a single control point (the master unit) and the combined synchronous output of the units in the MultiPac. Individual MTs share power, current, and load on both a dynamic and steady state basis.

MultiPac operation allows controlling the individual MTs through the master unit. Observation and control of each MT in a MultiPac can be accomplished by the connection of a communications interface device through the master unit or APS. Any MicroTurbine or the APS can be designated as the master unit. This unit then becomes the physical and logical control connection point for the entire MultiPac system.

Contact your Capstone Authorized Service Provider for additional information on establishment of a MultiPac system.

### MultiPac Grid Connect Operation

In Grid Connect operation, each MicroTurbine independently synchronizes to the grid. MultiPac functionality provides a single interface point for Start, Stop, and Power Demand control. It is not necessary to connect a modem or signals from an external power meter to each individual MT in a MultiPac, only to the master unit.

## MultiPac Stand Alone Operation

In Stand Alone operation, MultiPac functionality provides the capability to synchronize the voltage source outputs of the individual MTs such that they share power and current on both a dynamic and steady state basis. The master MicroTurbine unit broadcasts synchronization data to the other units over a dedicated Capstone-proprietary digital communications bus.

## MultiPac Redundancy

In MultiPac operation, if an individual MicroTurbine fails (shuts down due to a fault), the remaining units will continue to operate. If the master unit fails and communication is not possible, the entire MultiPac system will shut down. If the master unit fails, another unit in the MultiPac system can be manually programmed to be the new master unit, however the MultiPac system must not be operating while this re-configuration is performed.

## MultiPac Enable/Disable

Individual MicroTurbines must be disabled from a MultiPac system for service and maintenance. When service or maintenance is completed, the individual MTs must be added back into the MultiPac system (i.e., re-enabled). For data on the steps to Enable/Disable a MT unit in a MultiPac system, refer to the Display Panel Menus section on the top-level System Data Menu and the System Configuration submenu or contact your Capstone Authorized Service Provider.

### Changing the Master Unit in a MultiPac

In a MultiPac system, one MicroTurbine is the master unit. To assign a different MT to be the master unit, perform the following steps. The steps are presented in functional groups of steps for clarity.

<b>NOTE</b>	The following steps are performed on the MicroTurbine that was the old master unit in the MultiPac. Alternatively, comparable steps can be performed using CRMS software on a computer connected to the MicroTurbine User Interface Port.
-------------	---

- *Disable the old Master from the MultiPac*
  1. Log on with the User Password (see Logging On with a Password on page 22).
  2. Go to the **System Data** top-level menu.
  3. Navigate to the **System Configuration** second-level menu.
  4. Navigate to the **MultiPac <Enable/Disable>** third-level menu.
  5. Use the (+) or (-) buttons to select Disable; then press the ACCEPT button.

<b>NOTE</b>	The following steps are performed on the Display Panel of the MicroTurbine that will be the new master unit in the MultiPac.
-------------	--

- *Set the MicroTurbine that will be the new master unit to number 1*
  6. On the new master unit, log on with the User Password (see Logging On with a Password in the 'Logging on With a Password' section, or page 22).
  7. Go to the **System Data** top-level menu.
  8. Navigate to the **System Configuration** second-level menu.

9. Navigate to the **Turbine Number <Number>** third-level menu.
10. Press the "1" Numeric Keypad button to set the Turbine Number to 1; then press the ACCEPT button.
- *Enable MultiPac*
  11. Go to the **System Data** top-level menu.
  12. Navigate to the **System Configuration** second-level menu.
  13. Navigate to the **MultiPac <Enable/Disable>** third-level menu.
  14. Use the (+) or (-) buttons to select Enable, then press the ACCEPT button.
- *Reboot the new master unit*
  15. Go to the **System Data** top-level menu.
  16. Navigate to the **Reboot <No/Yes>** second-level menu. Use the (+) or (-) buttons to select Yes, then press the ACCEPT button.
  17. If there had been a telephone line connected to the modem in the "old" master unit, move the telephone line connection to the modem in the "new" master unit.
18. Go to the **System Data** top-level menu.
19. Navigate to the **System Configuration** second-level menu.
20. Navigate to the **Turbine Number <Number>** third-level menu.
21. Use the Numeric Keypad to set the Turbine Number to a unique value; then press the ACCEPT button.
22. Navigate to the **MultiPac <Enable/Disable>** third-level menu. Use the (+) or (-) buttons to select Enable, then press the ACCEPT button.

## ICHP Operation

The ICHP system has three modes of operation. These are:

- Thermal Bypass (default)
- Electrical Priority
- Thermal Priority

**Thermal Bypass** – In this mode, the exhaust diverter is locked in the fully bypass position, and the MicroTurbine can operate with a minimum water supply flow. The water flow must be able to absorb 3kW of thermal energy transferred from exhaust. This mode may be used when thermal demand is extremely low compared with the electrical load. All normal MicroTurbine control modes are supported.

**Electrical Priority** – In this mode, electrical power output is set to the desired level, and water temperature is set to a fixed temperature setpoint – allowing independent electrical and thermal operation. Efficiency will vary depending on both electrical and heat load requirements. Electrical Priority can be used in either Grid Connect or Stand Alone modes of operation.

In Grid Connect, the MicroTurbine is set to a fixed electrical output (in most cases, the maximum output), and water temperature is set to a fixed setpoint. During operation, the diverter adjusts exhaust flow through the heat exchanger to maintain water temperature. System efficiency will drop as exhaust is bypassed to maintain water temperature.

This mode is typically used when either a fixed or maximum electrical output is required and usually sets a higher value, hence a higher priority on the electrical output rather than the heat output.

In Stand Alone, the MicroTurbine is programmed to follow the electrical load. As in Grid Connect, the water temperature is fixed. The diverter attempts to maintain a constant water temperature, despite the varying electrical output.

**Thermal Priority** – In this mode, the water temperature setpoint is fixed and is maintained by automatically varying the MicroTurbine electrical output. During this time, the diverter is fully closed, routing all the exhaust heat through the heat exchanger. If the MicroTurbine is operating at its minimum speed and power (idle), the diverter will begin to open if the water temperature begins to rise above its setpoint. At no time, will the heat exchanger be allowed to operate at an unsafe temperature.

This mode is typically used when maximum fuel efficiency is desired and electrical output is secondary. However, maximum efficiency can be maintained as long as minimum heat load can be achieved without opening the bypass. Thermal Priority can be used **only** in Grid Connect mode, and cannot be used in Stand Alone operation.

## MicroTurbine Preventive Maintenance

This section details the preventive maintenance procedures that must be performed on the Capstone MicroTurbine.

**NOTE**

Failure to provide proper maintenance will void the MicroTurbine warranty. Users do not perform the following MicroTurbine maintenance procedures, but it is important for users to be aware of them.

Only Capstone Authorized Service Providers can access the inside of the MicroTurbine enclosure (except for accessing the User Connection Board in the UCB/JUCB).

Only Capstone Authorized Service Providers can perform maintenance on the MicroTurbine components.

**WARNING**

The MicroTurbine system generates and uses voltage levels that can injure or kill. Obey all safety precautions when you work with or around electrical equipment.

## Scheduled Maintenance

The tables listed below detail the preventive maintenance schedules of the C65 MicroTurbines under normal environmental conditions. This information is provided for your reference. Only Authorized Service Providers are permitted to access MicroTurbine components and perform these maintenance tasks. Service intervals may differ between specific MicroTurbine models.

### C65 Standard Industrial package – Gaseous Fuels

Maintenance Interval	Component	Maintenance Action	Comments
24 months	UCB Battery	Replace	
4,000 hours	Engine Air Filter	Inspect	Replace if application requires - see Note 1
	Electronics Air Filter	Inspect	Clean if necessary - see Note 1
	Fuel Filter Element (External)	Inspect	Replace if application requires - see Note 1 (Not required for Gas Pack)
	Fuel System	Leak Check	Refer to "Gaseous Fuel Fittings and Components" section below for recommended procedure
8,000 hours	Engine Air Filter	Replace	
	Electronics Air Filter	Clean	
	Fuel Filter Element (External)	Replace	Not required for Gas Pack
	Igniter	Replace	See Note 2
	ICHP Actuator	Replace	
20,000 hours or 3 years	Battery Pack	Replace	Refer to Battery Tech Ref (410044) for expected life vs duty cycle, and "Battery Maintenance During Storage" section below for recharge intervals
20,000 hours	Injector Assemblies	Replace	
	TET Thermocouple	Replace	
	SPV	Replace	Replace with Woodward Valve Upgrade Kit
40,000 hours	Electronic Components: ECM, LCM & BCM Power Boards, BCM & ECM Fan Filters, Fans, EMI Filter, Frame PM	Replace	Kits available for each major configuration
	Engine	Replace	Use Reman or New Engine Replacement

<b>NOTE 1</b>	Filters may require more frequent attention based upon environment, installation, and/or air/fuel quality. Inspect new installations frequently to determine best inspection/replacement periods for air and fuel filters.
<b>NOTE 2</b>	Load profiles with frequent onloads and offloads may require more frequent igniter replacement due to igniter operation during injector switching.

## C65 Stainless Steel Package – Gaseous Fuels

Maintenance Interval	Component	Maintenance Action	Comments
6 months	Gas Detector	Calibrate	Refer to Applications Guide 480010 for procedure
12 months	Magnehelic Pressure Gauge (CID2)	Calibrate	Refer to Applications Guide 480010 for procedure
	Electronics & Harnesses: ECM, LCM, BCM, UCB, Engine & Intra-Controller Harnesses	Inspect	Visual check for cracking and evidence of corrosion or deterioration
24 months	UCB Battery	Replace	
4,000 hours	Engine Air Filter	Inspect	Replace if application requires - see Note 1
	Electronics Air Filter	Inspect	Clean if necessary - see Note 1
	Blower Air Filter (CID2)	Inspect	Clean if necessary - see Note 1
	Fuel Filter Element (External)	Inspect	Replace if application requires - see Note 1
	Fuel System	Leak Check	Refer to "Gaseous Fuel Fittings and Components" section below for recommended procedure
8,000 hours	Engine Air Filter	Replace	
	Electronics Air Filter	Clean	
	Blower Air Filter (CID2)	Clean	
	Fuel Filter Element (External)	Replace	
	Igniter	Replace	See Note 2
20,000 hours or 3 years	Battery Pack	Replace	Refer to Battery Tech Ref (410044) for expected life vs duty cycle, and "Battery Maintenance During Storage" section below for recharge intervals
20,000 hours	Injector Assemblies	Replace	
	TET Thermocouple	Replace	
	SPV	Replace	Replace with Woodward Valve Upgrade Kit
	Electronics & Harnesses: ECM, LCM, BCM, UCB, Engine & Intra-Controller Harnesses	Replace	Kits available for each major configuration
40,000 hours	Electronic Components: EMI Filter, Frame PM	Replace	
	Engine	Replace	Use Reman or New Engine Replacement

<b>NOTE 1</b>	Filters may require more frequent attention based upon environment, installation, and/or air/fuel quality. Inspect new installations frequently to determine best inspection/replacement periods for air and fuel filters.
<b>NOTE 2</b>	Load profiles with frequent onloads and offloads may require more frequent igniter replacement due to igniter operation during injector switching.

## Preventive Maintenance

Preventive maintenance activities for the MicroTurbine Inlet Filter, External Fuel Filter, and for the Battery Pack are described in the following paragraphs.

### MicroTurbine Inlet Air Filter

The engine air inlet filter should be inspected periodically to ensure unrestricted flow of clean combustion and cooling air to the generator and turbine engine. The recommended interval for this inspection is every 4,000 hours of operation or annually, based on clean environment operation.

Outdoor operation, especially in areas subject to wind and airborne dirt or dust, will require a significant reduction in this interval. If the MicroTurbine is operated under unusual conditions, the filters should be checked more frequently to determine a site-specific service interval. Filters may require more frequent attention based upon environment, installation, and/or air quality.

**If specifically permitted by the Capstone Authorized Service Provider, the end user can replace the inlet air filter element. The Capstone Authorized Service Provider will provide instruction and oversight.**

**CAUTION**

The MicroTurbine requires clean, dust free air for operation. Do not operate the MicroTurbine without the inlet air filter in place or damage to the equipment can occur.

### External Fuel Filter

The optional external fuel filter element should be replaced periodically to ensure unrestricted flow of clean fuel to the MicroTurbine. This is necessary for MicroTurbine optimal performance. The recommended interval for this replacement is every 8,000 hours of operation. The service interval is based on typical clean fuel supplies found in the United States. Filters may require more frequent attention based upon environment, installation, and/or fuel quality.

**If specifically permitted by the Capstone Authorized Service Provider, the end user can replace the external fuel filter element. The Capstone Authorized Service Provider will provide instruction and oversight.**

**WARNING**

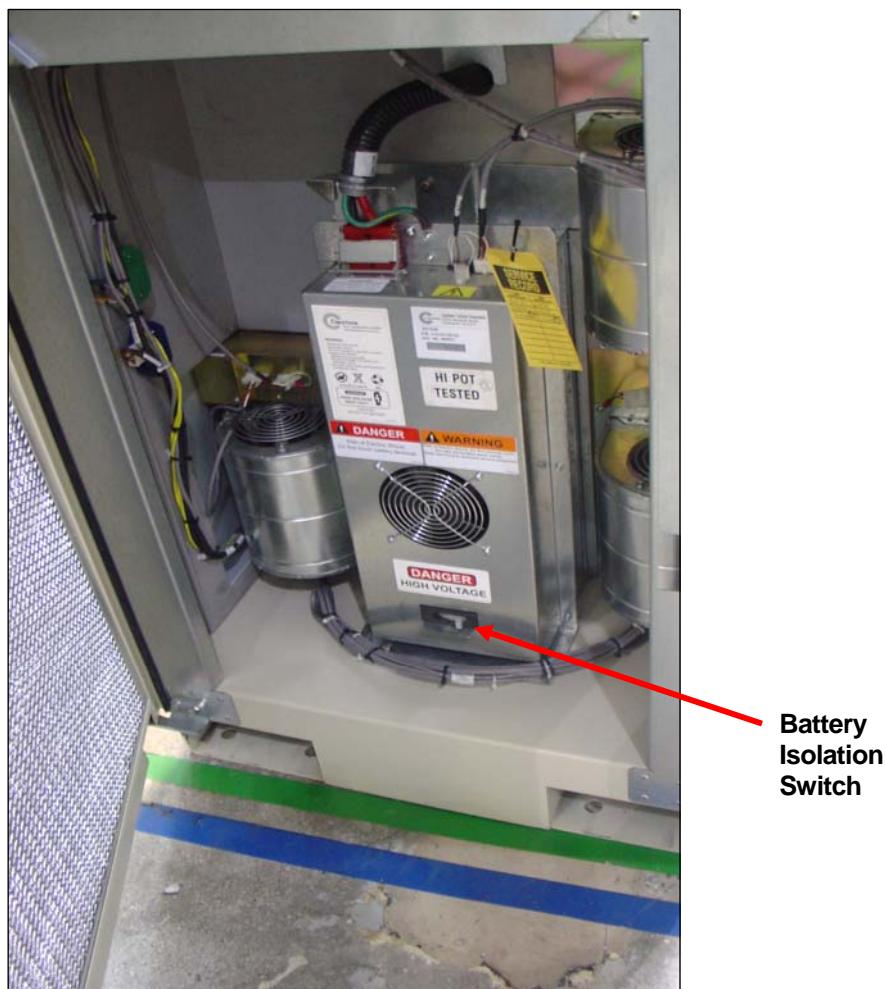
MicroTurbine fuel is flammable and explosive. An explosion can cause death or injury to personnel and/or damage to equipment. No open flame or smoking is allowed near the MicroTurbine.

## Battery Maintenance During Storage

The battery pack is a lead acid type, completely sealed, and maintenance free. The battery pack should be fully charged prior to storage and charged again prior to being put back into service. If the MicroTurbine is equipped with a battery, a Battery Isolation Switch is included.

MicroTurbines equipped with the Stand Alone option require maintenance for the battery pack. The battery pack is maintained through software during regular use, however battery packs stored for extended periods will become discharged and require service. Recharge intervals for battery packs in storage with the battery breaker **OPEN** are dependent upon the ambient storage temperatures.

The isolation switch should be set to OFF if the MicroTurbine is to be serviced or transported, or if the MicroTurbine will not be operated for a period of greater than two weeks. See the following photo showing the isolation switch.



**Battery Isolation Switch View, Lower Front of MT with Front Door Open**

The maximum recharge interval is specified in the following table:

<b>CAUTION</b>	The recharge intervals shown in the following table also apply to the Model C65 UCB battery stored unplugged from the UCB Board.
----------------	--

Storage Temperature °C (°F)	Recharge Interval - Days
<20 °C (68 °F)	180
20 °C (68 °F) to 30 °C (86 °F)	90
30 °C (86 °F) to 40 °C (104 °F)	45
40 °C (104 °F) to 50 °C (122 °F)	20
50 °C (122 °F) to 60 °C (140 °F)	5

<b>NOTE</b>	The maximum recommended storage temperature for a battery pack is 40 °C (104 °F). Long-term storage above this temperature may impact battery pack life.
<b>NOTE</b>	Capstone does not recommend storage over six months without charging or one year with charging, as it may contribute to a shortened battery life in the field.

### Sleep Mode

During the Sleep mode, the battery pack should be at a higher state of charge since it is called upon to start the MicroTurbine and produce transient power immediately after start-up. This reduces the recharge intervals for Sleep state. Recharge intervals for battery packs in Sleep mode are dependent upon the ambient temperatures as specified in the following table:

<b>NOTE</b>	The recharge intervals in the following table do not apply to the Model C65 UCB battery.
-------------	--

Ambient Temperature °C (°F)	Recharge Interval - Days
<20 °C (68 °F)	35
20 °C (68 °F) to 30 °C (86 °F)	22
30 °C (86 °F) to 40 °C (104 °F)	15
40 °C (104 °F) to 50 °C (122 °F)	10
50 °C (122 °F) to 60 °C (140 °F)	7

<b>NOTE</b>	A Grid Connect Idle Recharge or the Capstone External Battery Charger option may be used to perform the recharge as required. The battery voltage must be greater than 180 VDC on the C65 to perform a Grid Connect Idle Recharge.
-------------	--

When the recommended recharge interval is reached, the battery pack voltage should be recorded, and the battery pack must be recharged.

If the MicroTurbine is in operation, a Manual Recharge or a Shutdown Recharge will be sufficient to recharge the battery pack. Refer to the section on Stand Alone operation and the Display Local Battery Charge submenu for more data.

If the MicroTurbine cannot be operated, the optional Capstone External Battery Charger can be used to recharge the battery pack. Contact your Capstone Authorized Service Provider for details on the Capstone External Battery Charger.

## Battery Charge Management

The MicroTurbine system is designed to keep the battery approximately 80% charged during operation. This allows for sourcing and sinking of power transients in Stand Alone Mode. After an **OFF** command the system will recharge the battery to 90% before shutting down. This recharge can take up to 20 minutes.

During normal use, battery cells become charged unequally. Periodically, the MicroTurbine will perform an equalization charge cycle to keep the battery in top condition. Allowable times (in 4-hour minimum windows) must be programmed for when this can occur. Use the Capstone Remote Monitoring Software (CRMS) to set these allowable time windows, or contact your Capstone Authorized Service Provider for proper setup.

### Manual Battery Pack Equalization Charge

If the system is not operating or is in storage, a manual equalization charge may be commanded if the system is connected to the electric utility grid (see Grid Connect Operation). Initiate a Battery Pack Equalization charge as follows:

#### Using Display Panel

System Data Menu > Enter Password. The factory default User level password is 87712370.

Navigate to Stand Alone > Local Batt Chg > Enable. Press Accept.

Notice that battery pack equalization charge can take up to 4 hours.

#### Using CRMS or APS - CRMS

Select Settings > Battery Management. Set Equalization Charge Slider to Enable.

Notice that battery pack equalization charge can take up to 4 hours.

## Warranty

Each MicroTurbine ships with a standard warranty. Extended warranties are available. Contact your Authorized Service Provider for details on Capstone warranty terms and conditions.

## Troubleshooting

This section details basic troubleshooting procedures and steps that the user can perform on the Capstone MicroTurbine without accessing the inside of the enclosure. Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.

<b>WARNING</b>	The MicroTurbine system produces and contains high voltage. High voltage can injure or kill. Obey all safety procedures when you work around electrical equipment. <b>Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.</b>
----------------	---

## Incidents

The MicroTurbine continuously monitors a wide variety of parameters both internal and external to the system. An **incident** occurs whenever a measured parameter falls outside prescribed limits. Incidents include (but are not limited to) low fuel pressure, utility interruptions, and utility over voltages.

### Incident System Severity Levels

When the system detects an incident, it may take one of several actions, depending on the system severity level (SSL). Actions range from simply noting the occurrence and continuing to operate, to immediate shutdown of the system. The action taken depends upon the severity of the incident. The system will attempt a restart only if the severity of the incident will allow it.

Depending on the parameter and the magnitude of the incident, the event is classified as either a warning or a fault.

A **warning incident** is a condition that is outside normal operating parameters, but which does not require a system shut down.

A **fault incident** is a condition under which the system shuts down to prevent possible damage to the MicroTurbine or unsafe operating conditions.

### Incident Names and Codes

When an incident occurs, the **incident name** and **incident code numbers** are displayed on the Display Panel.

The incident names are:

- Internal Warning or Fault
- Fuel Warning or Fault
- Grid Warning or Fault
- Lo-Temp Warning or Fault
- Hi-Temp Warning or Fault
- Hi-Alt Warning
- E-Stop Fault
- User Connection Fault

Following the incident name will be a number up to five digits in length, called the incident or fault code. This code aids your Capstone Authorized Service Provider in determining the cause of the incident or fault.

### Internal Incident

An Internal Incident is one that is within a major subsystem of the MicroTurbine and is not recoverable by the user. In the case of an Internal Fault, the user should reboot the system. If unsuccessful in restoring normal operation, a Capstone Authorized Service Provider will be required to initiate repair of the MicroTurbine.

### Fuel Incident

The user should initially check the fuel supply to the MicroTurbine. Verify that the shut off valve is open. Ensure the line has the correct fuel pressure. Check the optional external filter to ensure that it is not blocked. If the problem persists, call your Capstone Authorized Service Provider.

### Grid Incident

This event is likely to be due to an electric utility grid disturbance. Check all breakers and fuses to ensure they are not tripped before troubleshooting. Reboot the system and attempt a start. If the problem persists, call your Capstone Authorized Service Provider.

### Lo-Temp/Hi-Temp/Hi-Alt Incident

Generally, these incidents are due to ambient conditions that are outside the design envelope of the MicroTurbine. Possible solutions would be to adjust the room temperature, ensure that adequate ventilation is provided, and verify that the air input and exhaust are not obstructed. Continued operation under these conditions may affect operation and cause damage to the MicroTurbine.

### E-Stop Incident

If the event display reads **MANUAL E - STOP**, check the optional emergency stop button and verify that it has been activated. If it has, reset the button, cycle power off to the MicroTurbine for 30 seconds, and turn the power back on. The fault should clear, and the system should resume operation. If it does not, call your Capstone Authorized Service Provider.

### User Connection Incident

User Connection incidents can be due to incorrect Grid Connect / Stand Alone settings, mode transition faults when in Dual Mode operation, or to indicate a possible problem with external equipment connected to the MicroTurbine.

## Viewing Incident Records

When an incident occurs the system records a snapshot of conditions at that time, called an Incident Record. Several incidents can occur in quick sequence, and the MicroTurbine will continue to operate or shut down depending on the severity of the incident(s).

The following parameters are recorded as part of the **Incident Rec** (Incident Record), and can be accessed using the Capstone Remote Monitoring Software (CRMS).

- Incident name
- Incident code number
- Cumulative number of starts
- Date and time
- Output power
- Engine speed
- Turbine exit temperature
- Fuel device command
- Ambient temperature
- Voltage and current on each phase
- Frequency
- DC bus and power supply voltage
- Several internal system temperatures

## Basic Troubleshooting Procedures

Basic Troubleshooting procedures are presented in the following paragraphs.

<b>WARNING</b>	<p>Users do not perform some of the following MicroTurbine troubleshooting procedures, but it is important for users to be aware of them.</p> <p>Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure. Users are permitted to open the User Connection Bay to access the User Interface Port.</p>
----------------	---

### No Lights on Display Panel

If no lights are present on the Display Panel, troubleshoot as follows:

<b>WARNING</b>	<p>Only Capstone Authorized Service Providers can perform the following troubleshooting steps.</p>
----------------	--

1. If Stand Alone equipped, open the front door. Make sure the Battery Isolation switch is set to **ON**. Then press the **BATT START** button on the Display Panel.
2. If Grid Connect, verify electric utility grid voltage is present on the phase terminals in the Power Bay.

## No Attempt to Start after ON Command

If no attempt is made to Start, after an **ON** Command, troubleshoot as follows:

1. Verify that the current communication device (Display Panel or User Interface Port) is the control device. See Control Device Authority and Priority on page 18.
2. Verify that **ON** command is consistent with the currently active dispatch mode. Refer to the section on Display Panel Menus for more data.

## Start Attempt Fails

If a Start Attempt fails, troubleshoot as follows:

1. If the system attempts but fails to start, an incident code will be registered as described in the previous sections.
2. The troubleshooting procedure is the same as for Unexpected Shut Down or Warning in the next section.

## Low Power Output

If Low Power Output is perceived, troubleshoot as follows:

1. Check your inlet fuel supply. Verify that the fuel isolation valve is open, and that the inlet fuel line has the correct fuel pressure.
2. Check your external fuel filter. Verify that the external fuel filter (if installed) is not blocked.
3. Check your inlet airflow, ventilation, and exhaust airflow. Verify that the inlet airflow and the exhaust airflow are not obstructed.
4. Check your ambient operating conditions and verify the expected power output due to temperature, altitude and other derating factors. Verify that ambient conditions are not outside the MicroTurbine design envelope.

## Unexpected Shut Down or Warning

When a warning incident occurs, no action is required by the user. When a fault incident occurs, the troubleshooting steps are as follows:

1. Attempt to restart. If unsuccessful, then verify the fuel, air, and electrical supply to the MicroTurbine.
2. Attempt to restart. If unsuccessful, then enter the user password and reboot the system through the Display Panel.
3. Attempt to restart. If unsuccessful, then cycle the power by shutting off power to the system, waiting 30 seconds, and turning the power back on.
4. Attempt to restart. If unsuccessful, then note the event number listed on the Display Window, and then call your Capstone Authorized Service Provider for assistance.

When required, your Capstone Authorized Service Provider will determine whether the event noted requires a service call or if the user can perform fault correction on site. Generally, the Service Provider will initiate a service call for Internal Fault codes. In most other cases, the Service Provider will recommend a possible course of action to return the MicroTurbine to operational status.



## - Notes -



## Product Support

Capstone Turbine Corporation is dedicated to the concept of quality to the owners and users of every MicroTurbine. Your MicroTurbine should operate without trouble. If you require maintenance support or other technical assistance, **please contact your Capstone Authorized Service Provider.**

Capstone Technical Support can assist you by providing contact data for your Capstone Authorized Service Provider.

Fill in this record with information about your Capstone Authorized Service Provider to allow easier access.

Capstone Authorized Service Provider Contact Information	
ASP Contact Name	
Address	
Telephone	
Facsimile	
E-mail	

The following information will help your Authorized Service Provider assist you.

System Information	
MicroTurbine Model No.	
System Serial No.	
Fuel Type	
Modem Phone No.	
Options Installed, and any configuration data	

### CUSTOMER SATISFACTION

We would love to hear feedback about your experience with our products.  
Please send e-mail to: [comments@capstoneturbine.com](mailto:comments@capstoneturbine.com)



## - Maintenance Log -

## Reference Documents

Refer to the following table for a list of Capstone reference documents, as required.

Document Part No	Description
410001	Model C60/C65 Electrical Technical Reference
410052	Grid Connect (GC) Operation Technical Reference
410053	Stand Alone (SA) Operation Technical Reference
410054	MultiPac Operation Technical Reference
480014	Model C65 Integrated CHP Application Guide

## Capstone Contact Information

If you have additional questions, please contact:

### Capstone Applications

Toll Free Telephone: (866) 4-CAPSTONE or (866) 422-7786

Fax: (818) 734-5385

E-mail: [applications@capstoneturbine.com](mailto:applications@capstoneturbine.com)

### Capstone Technical Support

Toll Free Telephone: (877) 282-8966

Service Telephone: (818) 407-3600 • Fax: (818) 734-1080

E-mail: [service@capstoneturbine.com](mailto:service@capstoneturbine.com)

### Capstone Technical Support (Japan)

Service Telephone: (818) 407-3700 • Fax: (818) 734-1080

E-mail: [servicejapan@capstoneturbine.com](mailto:servicejapan@capstoneturbine.com)